

# EXE

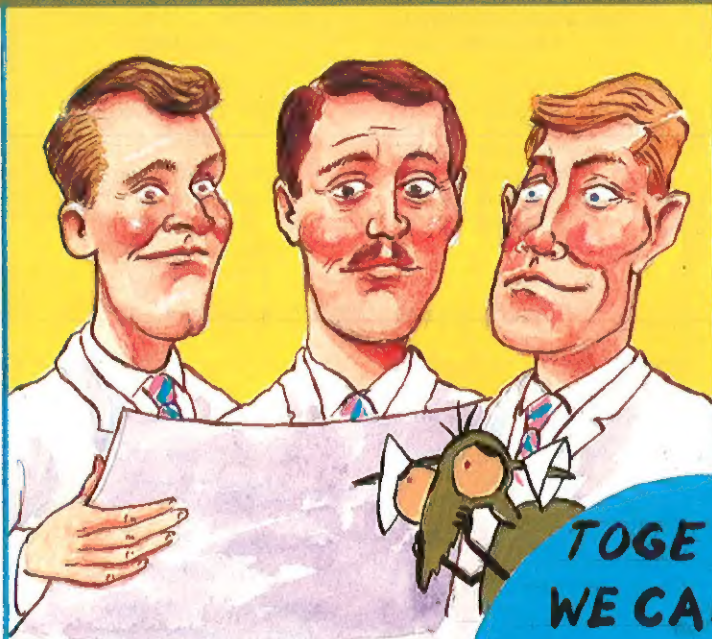
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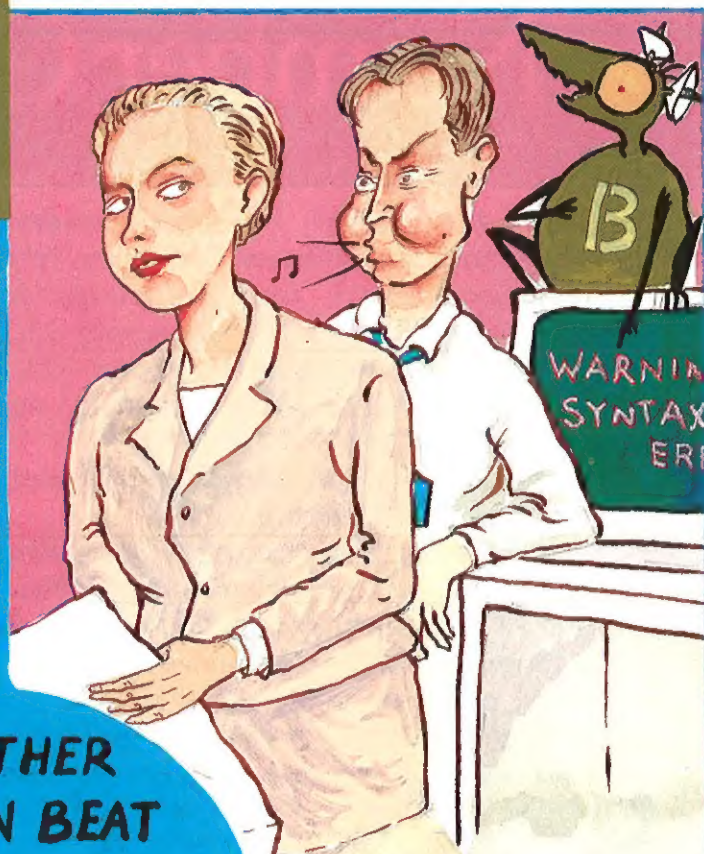
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The Software Developers' Magazine

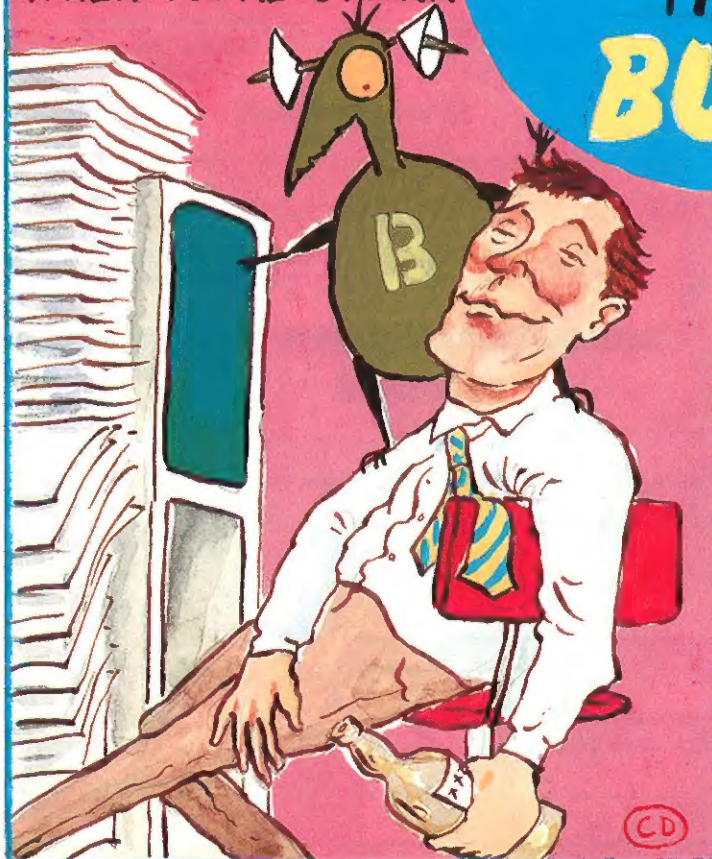


SHOW YOUR CODE  
TO FRIENDS



NEVER IGNORE  
COMPILER WARNINGS

DON'T PROGRAM  
WHEN YOU'RE DRUNK



## TOGETHER WE CAN BEAT **BERTIE** THE **BUG**

BEWARE, BUGS APPEAR  
AT AWKWARD MOMENTS



Die, Bertie, die!  
In-depth debugging coverage this month.

What's this? Darrel Ince on the sauce?  
Alcohol and error guessing don't mix.

Stand alone debuggers:  
We test the top five to destruction.

Processor design: why DSP's image is unfair.

A lightweight compiler gets heavyweight OOP.  
Turbo Pascal V6.0 hits the streets.

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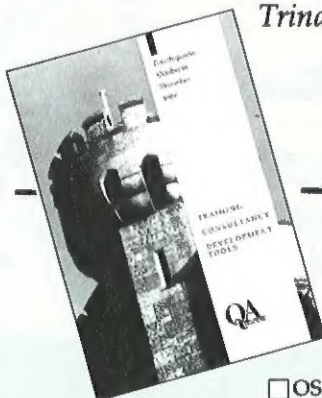
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### Pronunciation

The name of .EXE Magazine is pronounced to rhyme with 'not sexy magazine'.

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Prof Darrel Ince explains what IBM does with its more difficult employees, and suggests how to get by without somebody useless in your programming team.

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# Debugging with Double-think

*According to popular myth, Real Programmers do not need anything more sophisticated than a hex dump to debug their programs. Ron Newsham says that even this should be unnecessary.*

Formal methods are being developed so that you can reason mathematically that a design is correct. Total Quality Management programmes are developed to reach the magical 'Zero Defects' standard. Formal inspection methods are introduced to ensure that code conforms to requirements. These are good things, but there is a more fundamental way of encouraging error free programs.

Psychologists tell us that we have a mental model of the world. This model sets a standard against which we compare reality. Incoming information from our senses is filtered by this model. We only accept information that agrees with our model, otherwise the amount of information that we receive would cause a serious overload. But if some information is accepted, other information that does not agree with our model is rejected. This happens automatically and quite unconsciously. Psychologists call this 'perception'.

You can program this mental model to accept or reject different things. This is called a 'set' by psychologists. The mental set that you have affects your self image, approach to work, hobbies and life in general. If you have a negative self image, this will be reinforced by the mistakes you make. On the other hand, a positive self image minimises mistakes and reinforces successes. This is why you are told to be positive about yourself and 'go for it'!

Why all this 'pop psychology' in a magazine for programmers? As a programmer, you will create designs and code that should be perfect and not need to be checked, but they are frequently found to contain bugs. Why should this be? As a highly trained professional, mistakes should not occur. The trouble is that the mind is set to expect work that is perfect and error free. Errors are simply not seen. Although this model is wrong it is difficult to go through life expecting everything you do to be wrong. That way lies madness (or at least clinical depression).

You, of course, are not like this - as an ego-less programmer you know that you are likely to be fallible. However, because the mind set filter works automatically, it is easy to forget the fact that it is operating. There are any number of common errors that everybody knows about, errors that are so basic that nobody with more than two minutes experience will make them. Even when you edit a program for the thirty-second time, mutter the magical incantation 'this time ...', and

compile it, you can easily overlook the fundamental bug that has been there all along simply because you do not expect to make such a trivial mistake. Just as spelling check programs might correct the words that you type but not check for the correct word in context, compilers are good for finding errors in syntax but not in the program's logic.

It is too easy to assume that the program is correct simply because the compiler did not complain.

Be honest, have you ever written a document, passed it through your favourite spell-check program and painstakingly proof-read it. Then you issue it. The first person to glance over the issued document even casually is the one who notices the glaring error on the first page where the company's name is spelled incorrectly.

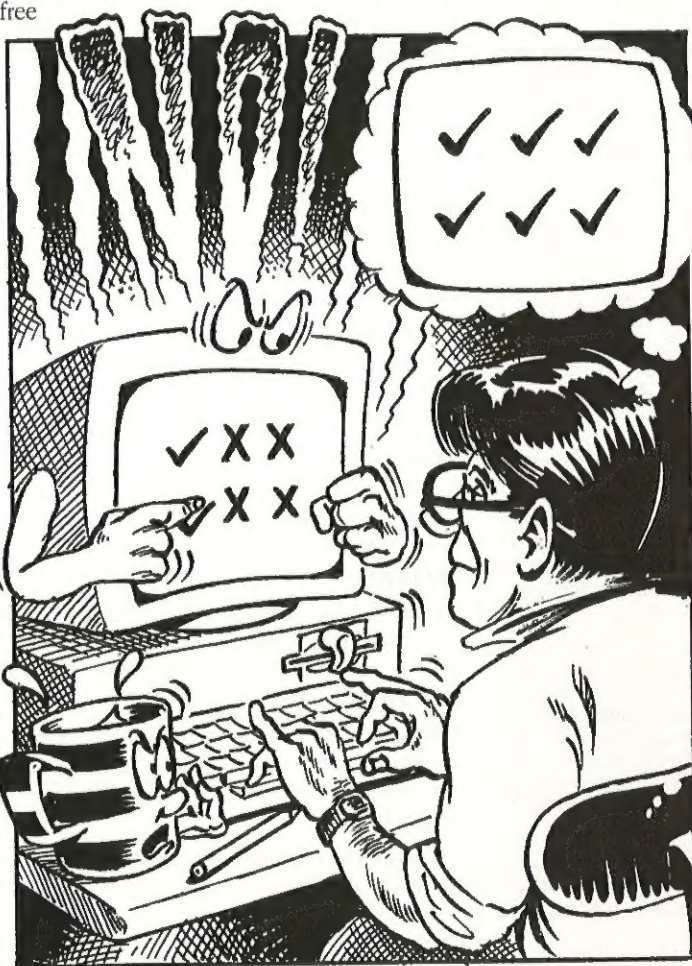
A good deal of time, effort and frustration can be saved if you program your mental model to realise that those simple errors will occur. By all means write your code thinking that it is the most perfect piece of code ever written. Then read through the code you have written actively looking for errors. Suspect everything - the bugs are there! You only need to open your eyes to see them. Nobody else need know that you think that there may be something wrong. Even

when you are happy with the code, there is still room for errors. Get somebody else to check it, or read it to them. Time spent getting it right from the start will pay dividends.

Trendy window based symbolic debugging tools that know all about the target environment are fine and well, but the real breakthrough in debugging is to set your mind to **see** your errors before they are committed to object code.

EXE

*For the last two years, Ron Newsham has been training software engineers as to how to write programs in C and generally how to drive computers. Prior to that he was a software engineer for six years. He also teaches people to be more creative and use their minds more effectively.*



## ADA COMPILERS

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## THE C LANGUAGE

Microsoft C V6 is a complete rewrite with improved optimisation and a new Programmer's Workbench. High C V1.6 has been considerably improved, with better Microsoft C compatibility, and new documentation.

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## Windows Show

The Windows Show will be held on Feb 12th-14th 1991 at Olympia 2, London. It is to include a Windows Developer's conference, with speakers brought in by Microsoft. Further information from IT Events on 0256 83456.

## Prolok missed

In our grand survey of software protection schemes, we omitted the Prolok software protection scheme, which is marketed in the UK by the Prolok Company (02406 2358). Our apologies to the company, which also offers ROMLOK-P (which is a dongle) and is on the point of releasing a software package which, it claims, will provide generic access control for LANs.

## MS-COBOL

Microsoft has released V4.0 of its MS-DOS and OS/2 COBOL compiler. Based on Micro Focus COBOL V2.4 compiler engine, the package comes with the Programmer's WorkBench V1.1 (complete with help files containing syntax diagrams for the whole COBOL language), the usual extra tools (but note that this CodeView only runs under OS/2; another debugger is supplied for MS-DOS work) and SQL Server support. The package costs £550.

## UK base for PDC

PDC Prolog used to be 'Turbo Prolog', and it is made by a Danish company. Intellisoft (0753 889972) has just been appointed UK distributor for the product, which has come on since its Turbo days. As well as the MS-DOS version (£119), you can now buy an OS/2 version (£595), an SCO UNIX version (poa) and a Prolog Toolbox (£125).

## Gas into CASE

British Gas has created a subsidiary, Information Architects, to market a new CASE tool called 'Architech' (geddit). The product was originally developed for in-house use, and runs under non-GUI GEM on MS-DOS machines. A Windows 3 version will follow. Prices start at £125,000 for a 10 user system. Contact IA on 0753 831540.

## Turbo Pascal V7.0?

Borland's explosive (literally) launch of Turbo Pascal 6.0 ended with some hints of future releases. There was a sneak preview of Turbo Pascal for Windows and Chuck Jaztzevski, Borland's star software engineer, mentioned in the last words of his speech that Borland was committed to support 'other operating systems' in the future. Hmmm.

## Microsoft opens Windows

Microsoft is to publish the internal data formats used by its Windows programming environment. With the next release of Windows, third party manufacturers, such as compiler-writers Jensen & Partners International (Modula-2, C) and Zortech (C++), will have access to the relevant documentation covering internal data structures, stack frames, object modules and so on. There will also be new APIs, designed to help tool developers to get inside Windows. Previously they were (in theory) obliged to do some rather heavy reverse-engineering on Microsoft's own Windows products.

Microsoft calls this strategy 'Open Tools', and hopes that it will encourage the development of a wide range of Windows tools such as debuggers, resource editors and so on. Developers will no longer need to buy the Microsoft SDK to develop Windows applications; they will be able to get by with an ordinary copy of Windows and a suitable self-contained Windows development product (eg Turbo Pascal for Windows or TopSpeed C++ for Windows).

Niels Jensen, Chairman of JPI, told .EXE: 'Great news for programmers, and good news for Application Development Tool suppliers such as ourselves. Microsoft's Open Tools strategy further endorses our commitment to provide programmers with a Windows capability across the TopSpeed range of languages.'

## New PS/2s

IBM has announced a big batch of new PS/2s. Top of the range are two 80486-based machines: the Model 90, which costs from £8500, and the Model 95, from £8960. Both machines feature an exchangeable processor board (available at 25 MHz and 33 MHz), so it should be easy to upgrade when the 80586 comes out. They have 8 MB of 70 ns RAM on the motherboards as standard, expandable to 32 MB. The CPU can address this memory via its own 64-bit data path. Both systems access volume data (hard disk, CD-ROM drive etc) via a Micro Channel SCSI adapter, which has its own 512 KB cache. The minimum hard disk size is 160 MB and the larger machine, the Model 95, can accommodate up to 1.6 GB internally plus 2.24 GB externally. However, the feature probably of most interest to software developers is the new XGA video standard, built into the motherboard of the Model 90 and supplied as an MCA card with the Model 95.

The XGA, which was produced at IBM UK's Hursley site, offers a maximum screen resolution of 1024 by 768 by 256 colours, using 1 MB of video RAM. It also has a 'direct colour' mode, intended to give a near-photographic effect, which is 640 by 480 by 65,536 colours (which by my reckoning leaves 50 KB unaccounted for). All VGA modes are supported, and existing VGA applications (even those that access registers) should run unchanged. DOS applications that used the earlier 8514/A Display Adapter, and stuck to the published interface, will also run ok; but if you used the video registers directly or wrote an OS/2 non-PM application then you have had it. IBM has arranged the following set of device drivers: DOS V3.3 and DOS V4.0 (required for 8514/A emulation), Windows V2.11 and V3.0, OS/2 V1.1 and V1.3, SCO

UNIX System V/386 Release 3.2 and AutoCAD Release 10.

The XGA board is a busmaster with its own processor. This can fetch and store information from main memory independently of the CPU, so improving the machine's overall performance. Features offered by the XGA include a cursor sprite and 'scissoring' - movement of on-screen data - ideal for speeding up WIMP operations. IBM is to publish the XGA register interface next year, so it looks as though XGA is set to become the next graphics adapter standard. For more information on the new PS/2s, tel (081) 995 7700

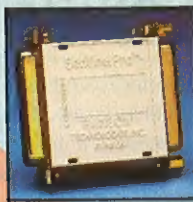
## OS/2 V1.3 announced

Microsoft and IBM have released the low-memory upgrade to OS/2. The new package can now operate within 2 MB of RAM (3 MB if you want the Extended Edition add-ons), hard disk (sorry, hard file) use can be reduced with a new selective installation program. OS/2 V1.3 is also faster, with particular improvements in its LAN file-handling and printing. Intelligent Environments, the manufacturers of Applications Manager, ran some existing applications in a benchmark test, and estimate V1.3 to run applications around a quarter faster than V1.2.

As predicted, Adobe Type Manager is now implemented, with a few standard fonts thrown in gratis. And REXX is now packaged with Standard Edition as well as Extended, allowing it to be used as a standard macro language for stand-alone applications. All this is downwards compatible, so existing applications can take advantage of the new features. New APIs have been added to allow fine tuning of the new print spooler, and to control the drag/drop and spin button functions. Prices remain the same: \$256 Standard Edition, \$611 Extended.

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**USXC**

*USXC is a German-written real time multi-tasking executive distributed by Creative Data Systems (0256 840646). Targeted at 8086, 8051, 8096, 68000, 68020, 68HC11 and Z80 processors, it offers dynamic task and resource management, plus inter-task communication. The software is configurable, ROMable, is supplied as C code as well as assembly and compiles to just 3 KB of object code. The price is £1680.*

**Prolog update**

*Following our piece on ESL's Prolog-2 for Windows 3, we've had a note from Quintec Systems Ltd, pointing out that its professional Prolog development system is also now out in Windows 3 form. Chief boons are a full DDE link system, and expert system and OOP toolkits. Quintec can be contacted on 0865 791565.*

**Now they're giving it away**

*Academics can, if they hurry, get hold of a free Ada compilation suite for their Sun-3 or VMS systems. The offer comes from Tartan Inc, which will provide colleges or universities with a full Ada compiler, the run-time system, a source-level debugger, cross reference-tool, object file utilities and a full set of documentation. Technical support is included, and the market value of the products range from \$15,000 to \$70,000. Offers are, unsurprisingly, limited and you have until December 31 to get them in. Phone John MacGregor at Thornbrook: (0993) 83133.*

**Dictionary Engine DLL**

*Microlytics are now shipping Spell Finder 7.0 for Windows, a spelling engine in DLL form. The library takes up 48 KB, and has support for all the major European languages. Included with package are a number of source code examples for integrating spell checking functions into external application code. Microlytics are on 0533 625062.*

**Qedit 2.1 For Sale**

*Fans of Qedit, the shareware programmer's editor by Semware, will be pleased to know that Grey Matter is now selling the fully boxed product in this country. The package includes complete printed manuals and registration card. Support from the US is reputedly excellent, as with most shareware products, and there's an OS/2 version too. Qedit 2.1 Advanced costs £55 (DOS or OS/2 version). A DOS package including a TSR version of the editor is available for £69. Contact Grey Matter on 0364 53499, or try your local bulletin board.*

**OpenWindows Source**

As per the season of goodwill, Sun Microsystems (0276 20444) has released the source code for its OpenWindows application development environment. This includes the full code of Sun's X11/News system, the fully X compliant implementation of PostScript windows. Also included is the source of OpenFonts, Sun's non-proprietary font scaling technology (including 57 scaleable Folio fonts), and Sun's implementation of the OPEN LOOK toolkit.

The source is available entirely free of charge - you just pay for the media. Unfortunately, the media cost \$995. Available from January 1st from your nearest Sun distributor.

**Batch To The Future**

Readers may remember an irate letter from a Mr Ian Butterworth in October, complaining about the current state of .BAT compilers in general, and Hyperkinetix's The Builder in particular. We've now discovered a compiler which seems to work as per Mr Butterworth's requirements. BAT-TOCOM from a UK company Clockwork Software implements all the standard DOS and BATCH commands, as well as supply a number of extra functions, such as large display fonts and simple windowing. It is limited (as the name suggests) to 64 KB of code, but can support overlaying. There's no copy license required for compiled code. It costs £65.

Clockwork has got a few other DOS utilities up its sleeves, including a redundant code analyser called FOSSIL and a

rather good memory editor called MAP. My favourite is its empty disk space analyser HAVEWE, which has the syntax 'HAVEWE 300K on B:'. FOSSIL and HAVEWE cost a tenner each, and MAP is priced at a very reasonable £25. Clockwork is on 0705 483217.

**GEM Sour Grapes**

Digital Research has kindly sent us a copy of Artline V2.0, which is its latest PC-based graphics package. I passed it to our Art Department, and she reports that it is pretty good (better than GEM Draw or DrawPerfect), although a little slow. She particularly likes the powerful colour-blending features and the ability to make text follow curved lines.

Artline is a GEM application but, unlike previous DR graphics products, it is not bundled with GEM Desktop - it is to be sold as a 'DOS' application. Although DR denies that it is dropping GEM, any developers still using it will hardly be encouraged by the following extract from the DR press release: 'Why is there so much confusion about [Microsoft] Windows and GEM? Simply because GEM is not a GUI whereas Windows V3.0 is a GUI. GEM is a library of routines that can enable you to create an application that uses GUI features.' 'GEM', I may remind you, stands for Graphics Environment Manager. A fancy name for a library, or what.

Artline V2.0 costs £395 and is available now. Upgrade deals available include... hold on, some late news just came in: CP/M, was not after all an operating system; just a library of routines that you could use to access files. BDOS Error on A and out.

**Babbage's Engine**

The Science Museum in London is playing host to an attempt to construct, for the first time, Charles Babbage's Difference Engine No 2. Next year is Babbage's bicentenary, and the museum intends to celebrate with a special exhibition, beginning in July, with the working Difference Engine as the centre-piece. The opening of the exhibition will coincide with a special International Conference on Computing, held under the auspices of the Institution of Electrical Engineers at Imperial College, London.

Babbage's own attempt to build the engine, which was ended by the withdrawal of his sponsorship, was previously thought to have been doomed because of the impossibility of manufacturing mechanical parts to the required tolerances. The current £500,000 project, which is sponsored by a consortium of computer, electronic and communication companies, seeks to prove this theory wrong, and so redeem Babbage's image. They are still looking for extra sponsors, by the way; if you're interested call Lynn Foster on 071 938 8115.



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CIRCLE NO. 378

**Busman's Holiday**

Two conferences abroad that might be interesting to those of you who can swing the costs. Software Development '91 is the big Silicon Valley meet, with three days of intensive discussion with the likes of Stroustrup, Plum and Kahn, and exhibits by most of the big American developers. Cost (excluding accommodation): \$895. Tel: 0101 415 995 2472 for details. Nearer (but not much nearer) is the popular International Workshop on Software Engineering, at Toulouse. Registration cost is 4,700 French francs. Tel: 01033 1 5780 7000.

**Mea culpa, Stony Brook**

Apologies to readers raring for Stony Brook Pascal+ info. The truncated phone number given last month left contactees in mid-Atlantic. Stony Brook's full number is 0101 805 496 5837 - sorry.

**£30 Modula-2 for the Macintosh**

Real Time Associates (081 656 7333) is now marketing a Metrowerks Modula-2 compiler for Macintoshes for £29. The package includes a full optimising 68000 compiler with debugger. Standard Modula-2 implementation of I/O is included, as are a few limited graphics modules. Modules are limited to 1000 source lines. Mac users looking for a full MacApp-like support, with 68030 and co-processor compilation, should splash out on the full £150 system.

**Hypertext compiler**

A program which converts documentation into a pop-up hypertext system has been announced by Mike Lewis Computing (031 667 7685). The FactBox compiler takes simple text files with flagged cross-references, compresses it, resolves the cross-references, links the topics to an outline, and adds a help screen. Mike Lewis already produce an MS-DOS encyclopedia based on the system. A basic FactBox Compiler sells for £95, but you'll have to negotiate with MLC for copy licence conditions.

**Giftware**

Something for the WIMP in your family. Mickey Mouse, Dick Tracy and Indiana Jones(TM) Mouse Pads. £13 each from the MacWarehouse, Tel: 0800 181 332.

**Our No-Nonsense Christmas Warranty**

Finally, a reminder that .EXE hibernates in January, so please do not ring us up to query its non-arrival. Meanwhile, we should like to thank our readers and our advertisers for their support over the year, and wish you all a Merry Christmas with a Happy New Year, subject to the usual conditions.

**Assembly Help**

One of the many pains of assembly language coding is that any macros one writes never seem general enough for regular use. Apart from <K>POP\_ALL<k>, and a smattering of maths functions, it hardly seems worthwhile. Quantasm has just released a small macro and support library which should bear reuse. It's called 'PRINTF for Assembly Language' and that is pretty well what it does. It takes up less than 600 bytes of code, and comes with a flexible macro structure. PRINTF can format and print 32-bit, 16-bit and string data, with hexadecimal, signed and unsigned conversions (see our examples). The source code can also be easily modified to support user data types.

Quantasm has also released an update to its assembly code flow-charter, ASMFLOW Professional V2.0. Extensions to the old ASMFLOW include better macro support, a larger capacity for tree diagrams, 486 code and a hitch in price to \$199.95 (\$49.95 to old ASMFLOW users). Quantasm Corp is on 0101 408 244 6826.

```
printf    <Hello world.\n>
printf    <AX=$x BX=$x\n>, <ax,bx>
printf    <Filename: $s[11]\n>,<ds,si>
printf    <File size: $lu\n>,\n
          <[si].size.hi, [si].size.lo>
```

**The Portable COBOL**

Ryan McFarland has announced an upgrade of its RM/COBOL-85 compiler. Version 5 offers pop-up windows (which is more difficult than it sounds, on the diverse range of platforms that RM inhabits) and additional X/Open features. The software now supports some extensions from various other COBOL dialects: Read Previous, Start Less Than and Or Equal come from IBM VS COBOL.

The product uses a pcode system to attain easy portability. It is initially available on the IBM RISC/6000, MS-DOS, OS/2, SCO UNIX and 88000 based systems, with others to follow before the end of the year. The price for the MS-DOS development system is £1040; the run-time pcode interpreter costs an extra £125 for a single user version. Ryan McFarland is now part of Liant Soft-

ware Ltd, which can be contacted on 071 799 2434.

**Windowsmania**

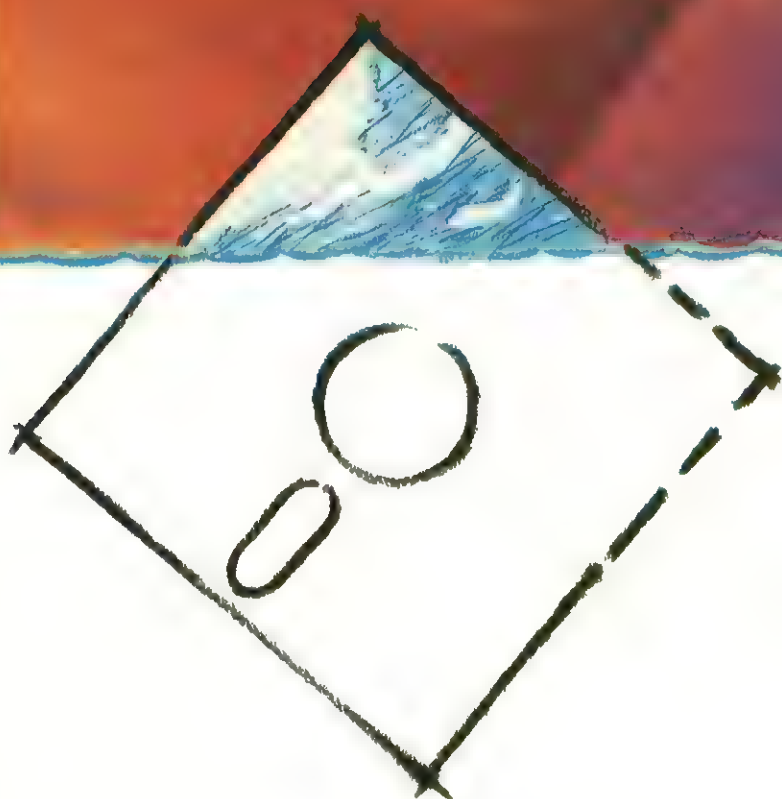
Just to put it all in perspective: Windows 3 has now surpassed 1.5 million sales (2.5 million, including OEM bundling). The UK accounted for over 60,000 shipments. According to Microsoft, seven out of 10 new software applications are designed for Windows, and more than 25,000 Windows SDKs have been shipped. A telephone survey by Sapphire International showed that 12.5% of those polled intend to install Windows instead of OS/2. Over 20% are already using Windows. Altogether, 45.2% of the total survey were users or expected to use Windows, against only 8.6% who were users, or planned to be users of OS/2. Microsoft's profits this quarter were up 77%.

**Pop Star**

The winner of our POP-11 competition (as drawn from the Editor's hat) was Mr D A Darlison of Dewsbury. Congrats to Mr Darlison; the copy of *The Annotated C++ Reference Manual* is on its way to you. The runners-up were Bill Tromans from St Albans, Peter James from Walsall and Mark Davies from Rowington: T-shirts go to each of them. Commiserations to the many other entrants.

The 11 items in the POP picture were: Pop<sup>1</sup> the paternal figure is popping<sup>2</sup> the champagne and popping<sup>3</sup> his clogs. The nursery-rhyme weasel is certainly reputed to pop<sup>4</sup>, and it has a pop-gun<sup>5</sup>. A balloon is popping<sup>6</sup>. There is a bottle of pop<sup>7</sup> and a bowl of popping breakfast cereal on the table. The TV is tuned to *Top of The Pops*<sup>8</sup>, and a pair of pop-socks<sup>10</sup> is drying on the aerial. Through the window, we can see a pawnbroker's sign, suggesting that we are near a pop<sup>11</sup> shop. So now you know.





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# Letters

*We welcome short letters on any subject that is relevant to software development. Please write to The Editor, .EXE Magazine, 10 Barley Mow Passage, Chiswick, London W4 4PH. Unless your letter is marked 'Not for Publication', it will be considered for inclusion on this page.*

## Passwords for Plastic

Sir,

Peter Collinson in his article on password (UNIX Regular, Oct 90), among other good ideas, says 'do not have passwords less than six characters' and 'do not have all digit passwords'.

If you have one of those convenient bits of plastic in your wallet or purse, just remember that your whole bank account relies on a FOUR DIGIT PASSWORD, and the keypad you use is visible to any bystander.

I religiously get all my PIN numbers cancelled with a nasty letter to the head office.

*Dave Fawthrop  
Computer Hyphenation Ltd  
Bradford*

## Where C++ is wrong

Sir,

Contrary to Dr Bailey's suspicions (Letters, October 1990), I am not a supporter of any particular object-oriented programming language; I always favour the language most suited to the job. If, like Dr Bailey, I wished to write compilers I, too, would probably choose C++.

But there is something deeper than this issue of horses-for-courses. Dr Bailey is clearly someone who, quite correctly, regards C++ as a better C and has little ambition beyond exploiting its improved

powers of abstraction and encapsulation. He should be aware that there are many organisations, hyped-up by the claims made for object-oriented programming, looking to C++ for order-of-magnitude improvements in productivity. It was, in the main, these organisations that I had in mind when writing my article. As I said, if object-oriented software development can live up to this hype no particular language will play much of a part; changing the development life-cycle will be vastly more important.

One company I know of which has been pondering C++, a major financial institution, has a background of software development in APL and Natural, both high-level environments easily accessible to programmers. The idea of companies like this moving to C++ just because of its object-oriented cachet is enough to give anyone nightmares.

*John Daniels  
Object Designers Ltd  
Herts*

## FORTRAN fan

Sir,

I have followed with interest the series *The Third Side*, but was rather surprised to see the sample program shown for FORTRAN in .EXE Magazine August 1990. On reading the article, I realise that this was meant to be a version in the original FORTRAN.

Figure 1 shows a FORTRAN 77 program equivalent. I sat down and coded it, because I felt that any casual reader of the article might think that a modern FORTRAN program would look like the *Third Side* example shown, while the reality is very different.

My example follows exactly the logic of the previous FORTRAN solution, with the following exceptions. The first test (for a valid triangle) rejects the cases where the sum of two sides is equal to the third since this results in a collapsed triangle which is a straight line. Also the read has been revised to use an 'implied DO' loop.

This is the only place where the array T is treated as such, and it would probably be easier to code and understand correctly if the three sides were called 'A, B, C' or 'X, Y, Z'; although modern practice would encourage SIDEA, SIDEB and SIDEC. One of the features of FORTRAN is that spaces are ignored anywhere within code, except in character constants. Although this has some bad side-effects, it means that you can refer to SIDEA as 'SIDE A', which may be more readable (but confuses editor searches on variable names).

The current draft standard (FORTRAN 90 - no longer known as '8X') introduces a number of other features which remove the arbitrary restrictions of FORTRAN; eg free format source code with significant blanks (so no more SIDE A). There are also many major enhancements, such as array handling; derived (user defined) data types including structures; pointers and program modules (packages) which are planned for the latest standard. These will make FORTRAN a winner for parallel processing of large array computations and provide most of the 'modern' features of other popular languages, with fewer dangers.

FORTRAN continues to be, and increasingly to become, a pragmatic, effective and readable language in which to write clear, efficient and maintainable code.

*George A Ruscoe  
Humphreys & Dean  
Software Consultants*

```
* This program tests for a valid triangle

PROGRAM TRIANG
  REAL      T(3)
  PRINT *, 'Enter lengths of 3 sides'
  READ *, (T(I), I=1,3)

  IF (T(1).GE.T(2)+T(3).OR.T(2).GE.T(3)+T(1).OR.T(3).GE.T(1)+T(2)) THEN
    PRINT *, 'This is not a Triangle'

  ELSEIF (T(1).EQ.T(2).AND.T(1).EQ.T(3)) THEN
    PRINT *, 'This is an Equilateral Triangle'

  ELSEIF (T(1).EQ.T(2).OR.T(2).EQ.T(3).OR.T(3).EQ.T(1)) THEN
    PRINT *, 'This is an Isosceles Triangle'

  ELSE
    PRINT *, 'This is a Scalene Triangle'
  ENDIF

  STOP 'Done'
END
```

Figure 1 - FORTRAN 77 solution of Triangle problem

# "AS YOU LIKE IT!"

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CIRCLE NO. 381

# Wot, no psychotic?

*In which Prof Darrel Ince admits to a narrow brush with the Demon Drink; he explains why IBM likes to employ hopeless gamblers and suggests what to do if you haven't got a psychotic in your company.*

You may think that the story I am about to tell you has little relevance to testing. Please bear with me: the lesson it taught me helped me sharpen up my testing considerably. Even if you think it has little relevance, it does contain some humour.

I was brought up in a small village in South Wales. My family was very religious and consequently I had to attend chapel every Sunday rather a large number of times. Each Sunday I would be scrubbed and buffed, and sent to both the Sunday services and Sunday school. At all these events I had to listen to rather forbidding preachers who would deliver the same message



week after week: that the fruits of the present and afterlife would only be gathered by those who worked hard. By the time I went to university, this message had been hard-wired into me.

After university, I worked for a company which developed real-time software on main-frame computers, in those days a notoriously hard thing to do. I was given the task of programming one of the subsystems of a rather primitive transaction system using an assembler language. Debugging facilities were few and steam-powered. I found detecting all the errors in the system was an extremely difficult task.

I used to come in in the morning, on time, with my ham sandwiches, collect the printout from the previous night's run, and pour over octal dumps looking for errors. Because I believed that hard work would enable me to gather the fruits of

the present life, I would work through lunch-time, printout in one hand, sandwich in the other.

This approach was only partially successful. I was working very hard, and beginning to suspect that the message about the present life and afterlife might be flawed.

This suspicion was heightened by the fact that I shared a room with a more experienced programmer, whose frequent habit was to take long, liquid lunches. In the afternoons he would lurch into the room, belch, glance over my shoulder and home-in on the error I had just spent four hours looking for.

## Drunk in charge

So, here was I, with a non-conformist upbringing, beaten at debugging my own programs by a drunk. I ascribed his superior performance to the alcohol, and devised a programme of experiments to test this hypothesis. Fortunately, before I undertook any experiments, I mentioned my problem to a senior programmer. He told me that my colleague's amazing debugging skills had

a=3	b=4	c=5		Error 1	Display values
0		0			0
X	0			0	
0	0	0		0	
	X	X		0	

Figure 1 - A simple decision table

command ok	d1 correct	d2 correct	d1>d2	no data	one date	no date
0	0	0	X	X	X	X
X						
0	X					

Figure 2 - Decision table for the AVERAGE program

nothing whatsoever to do with the beer, but had everything to do with the fact that he hadn't written the program.

The senior programmer said that developing software was very like giving birth to and bringing up a child: it is messy, uncomfortable and nothing useful seems to emerge for a long time. We tend to exhibit the same faults in the way we treat both our own software as we do our children. We have misconceptions about what they do, we think that they are perfect and we interpret their actions wrongly.

So the worst choice of person to debug a program, said this sage, is the person that wrote it. It is this precept that has guided me both in my teaching and as a consultant advising companies on quality assurance. My aim in this article is to describe some techniques to increase this independence: some of them are managerial, others are technical.

## Black team

Probably the most extreme implementation of the maxim 'let somebody else test your software' is the *black team*. This is a form of quality assurance organisation adopted by some of the divisions of IBM. A black team is a collection of staff who are called in after system testing has finished, and before acceptance testing starts. Its main function is to ensure that system testing has been carried out thoroughly, and that acceptance testing will not be too big an embarrassment to the developer.

IBM has an enlightened employment policy. It considers that *everybody* that it employs - even individuals who might, in most companies, be regarded as completely incompetent - is capable of doing some job well. A black team often contains staff who have not succeeded in other areas of a company. One black team that I met contained a secretary who had crashed every word processor which she had been given; a programmer who spent most of his salary on stock-car racing; an analyst who had had a run-in with an IBM manager, and had subsequently developed a pathological hatred of all IBM managers; and a programmer who was undergoing therapy. They formed the ideal team to carry out

system testing. They had no interest in the software they tested and each, in his or her own way, had a reason for testing a system to the extremes of its performance.

I asked some of the members of the team, 'What is a good test?' They told me that a good test was one which crashed the com-

***He would lurch  
into the room,  
belch, and  
home-in on the  
error I had spent  
four hours  
looking for***

puter, and an excellent test was one which crashed the computer and made it inoperative for hours on end. The project managers at IBM hold out the prospect of a visit from the black team in order to encourage their staff to test a system more thoroughly than they would normally do.

Another American phenomenon is the bug bounty hunter. Small companies usually resident in California are paid to test a system. They are usually given a small retainer, with a bonus for each bug that they discover.

In the United Kingdom we are somewhat staid, and rely on independent quality assurance departments who attach staff to projects. Such departments usually have a separate reporting line to a senior manager. If a project manager is not doing a good job testing a system, retribution descends upon him from a considerable height.

## Small alternatives

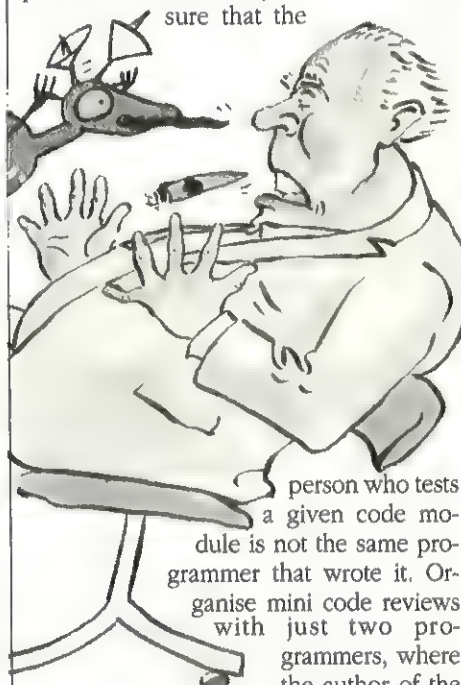
Given that you might work in a small company without a quality assurance department, or you do not have a ready supply of

psychotics, what can you do? There are a number of techniques that are available which, if they do not completely eliminate the bias that a software developer has in testing his software, certainly reduce it.

One of the most effective techniques is the technical review. A review is a meeting of software staff who examine a document or program code in order to detect errors. A code review would be a meeting of three or four staff who would systematically examine one module at a time looking for errors. They would not be involved in rectifying the errors, or suggesting corrections. Their job is simply to find fault.

Reviews sound awfully boring - they are - but they are immensely successful. At IBM, when they were introduced, they saved as much as 45% of project costs. The person who suggested reviews to IBM, Michael Fagan, received the largest bonus in the history of the company.

But what if your outfit is too small to use the full review process? There are still some practical measures that you can take. Make sure that the



module explains, line by line, exactly how it works. It's really surprising how many errors are detected by the program's author without the listener so much as raising an eyebrow.

comm error	date error	date diff error	no data error	one date error	results
					0
X					
	X				

Figure 2 - Decision table for the AVERAGE program

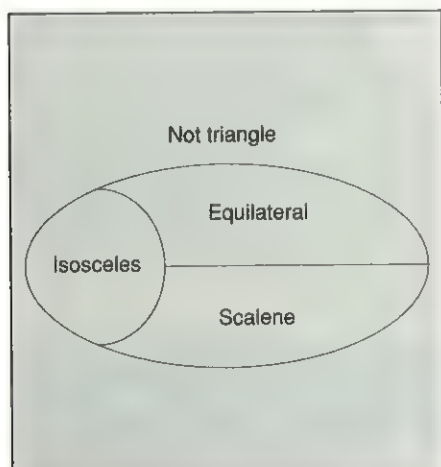
However, if you are a *very* small project, or you are an individual producing software by yourself, or you are in the unlikely position of not being able to find a psychotic in your company, then the rest of this article is about generating high-quality test data which is almost guaranteed to crash any system.

## Random testing

The first technique is random testing. If your program processes a large quantity of numbers or character strings, then use a random number generator to produce a large initial test-set. The advantage of using such a device is that a random number generator, as the name implies, is not biased by any human intervention. About five years ago, researchers at the Open University carried out a number of experiments to measure the effectiveness of random testing. During the experiment, which was performed on numerical software, (the sort of software used for simulating nuclear power stations or analysing the effect of wind on the wings of an aeroplane) the random number generator blew the software to pieces. It produced combinations of test data that no human tester had ever devised.

Another way of generating test data with no bias is to be methodical. There are three ways of generating test data in an organised way without introducing very much bias. They are called: decision table processing, equivalence partitioning and error guessing.

A decision table is just a table which contains entries known as conditions and actions. Actions will be carried out when a certain combination of conditions occur. An example of a simple decision table is



*Figure 3 - Set of test data for the Triangle problem*

shown in Figure 1. It has four entries. The first states that if the variable *a* is equal to 3 and the variable *c* is equal to 5, then some values will be displayed. The second entry states that if the variable *a* was not equal to 3 and the variable *b* was equal to 4, then error one would be displayed.

Decision tables have had a long history. Originally, in the 1960s, they were used as a primitive programming language for commercial data processing systems. They

## *IBM considers that absolutely everybody that it hires is capable of doing some job well*

were often implemented within COBOL compilers. For parts of a system which contained a large number of conditions and actions, a programmer would write a decision table in his program. A preprocessor would translate this into COBOL code, which would then be compiled as usual.

Decision tables went out of fashion in the early 1970s. I don't know why - I had always regarded them as a neat solution to the problem of convoluted, over-complex code. However, they re-emerged a few years later in a way that shocked the computing community.

Two American academics, Jim Goodenough and Susan Gerhard, were interested in testing techniques. Around about the time that they were carrying out their research, there was a very heated debate over the merits of program proving and formal methods of software development. Proponents of mathematical software development were fond of stating that program proving (writing down a mathematical specification and then proving that a program implemented it) would render most testing obsolete.

## Proof not Goodenough

Gerhard and Goodenough devised a testing technique using decision tables, and then generated test data which checked out a number of published programs which a

number of researchers had proved correct. The results were devastating. Almost all the programs failed under test. Goodenough and Gerhard's technique was so effective that it crashed high-quality programs that were the product of a lot of effort.

Their technique is a very low-tech one. All it involves is the tester identifying all the conditions that could occur when a particular feature of a computer system is exercised, and then exhaustively generating test data by examining all the possible combinations of events in the table. As an example, consider the test of a command that finds the average of a set of data which has been gathered over a particular period. Let us assume that when a user types the command

`AVERAGE date1, date2`

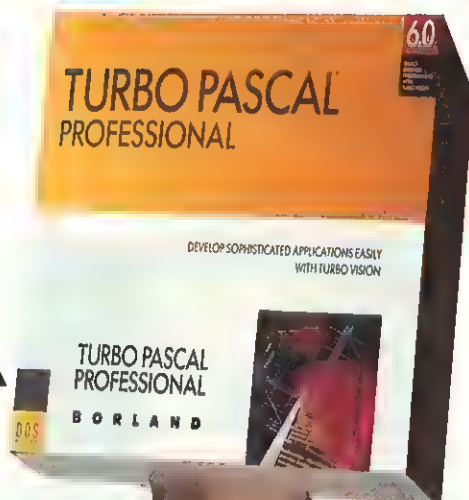
the average of the data collected between `date1` and `date2` will be displayed on a VDU, where `date1` is chronologically earlier than `date2`. The events that could occur with this feature are:

- The command name could be typed incorrectly.
- The first date could have the wrong format. For example, there could have been a reference to the 35th of September.
- The second date could have the wrong format.
- The first date may be chronologically later than the second date.
- The second date may be chronologically later than the date on which the command was typed.
- There may be no data collected for the period between the dates.
- Only one date was typed in.

An example of a fragment of a decision table showing some of these conditions and the actions that should be taken is given in Figure 2. It is interpreted as follows. Each condition row will either contain a zero, a cross or be blank. If a zero occurs then the condition is true, if a cross occurs then the condition is false and if blank, then it is irrelevant that this condition occurs. Similarly, action columns will contain zeros, and blanks. If a zero occurs, then the action is carried out; if a blank, then the action is not carried out.

Each row of this column represents a specific test. For example, the first row states that if the command was typed in correctly, the first date (*d1*) was correct, the second

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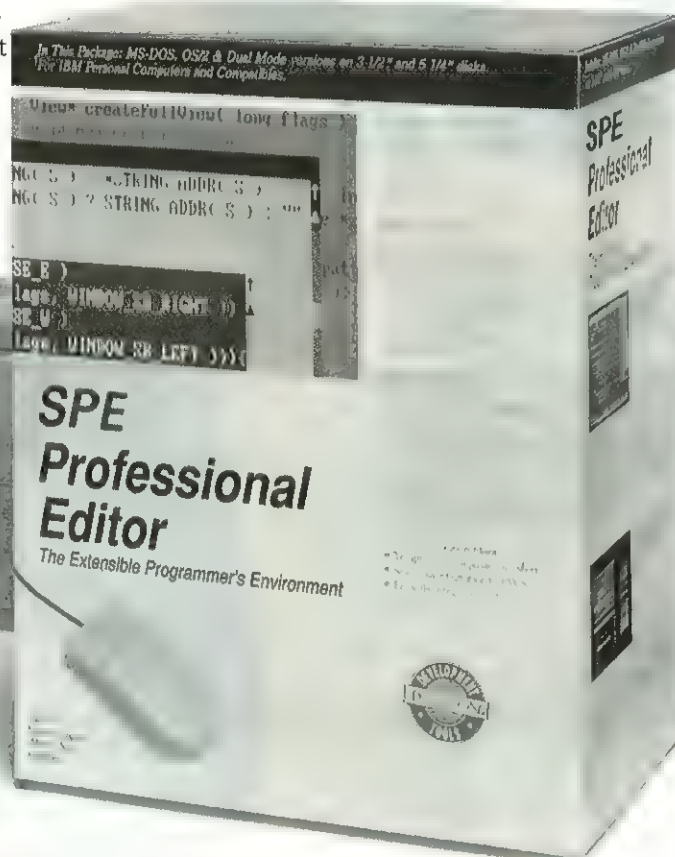
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date (d2) was correct, that data was available between d1 and d2, and two dates were typed in, then their results will be displayed.

These tables are produced from the system specification: the document that describes the properties of the system to be developed. As well as being an exceptionally good way of developing system tests, the technique is a thorough check of the system specification. Developers who use it to produce tests have reported to me that, by exhaustively moving through the table looking at combinations of conditions, not only are they able to create a good initial test set, but also find massive holes in the system specification.

## Error guessing

A second technique is called *errorguessing*. This involves the tester thinking of outrageous values for test data which would normally be regarded as an error. These are often the values that the user inputs first before they have properly read user documentation, or values which, although they might occur frequently, haven't been catered for in the software, and often blow it to pieces.

For example, a program for sorting integers could be tested by error guessed data which contained:

- Alphabetic characters.
- The largest integer capable of being stored on the computer.
- The negative of the largest integer that can be stored on the computer.
- A number which contains a large number of zeros.

And so on.

A final strategy is called *equivalence partitioning*. It is easiest to explain this technique with an example - the famous .EXE Triangle problem, which accompanies the *Third Side* series. Assume that a program has been written which reads in three integers and checks whether they represent the sides of a triangle, producing a suitable error message if they are not. If they do, then the program classifies them as being either equilateral (all sides equal), isosceles (two sides equal) or scalene (no sides equal).

The behaviour of the program can be characterised in terms of its test data - see Figure 3. Each area represents test data which

n = 3	x at position 17	decision table
n = 50	x not in array	decision table
n = -1		error guessing
n = 11000		error guessing
n = 0		error guessing
x largest integer on computer		error guessing
n = 1	x at a[1]	error guessing
n = 1	x not at a[1]	error guessing
n = 23	x at a[23]	equivalence partitioning
n = 23	x at a[24]	equivalence partitioning
n = 100	x at a[100]	equivalence partitioning
n = 100	x at a[99]	equivalence partitioning
n = 100	x not in a	equivalence partitioning

Figure 4 - Testing the FIND program

exercises the program the same way. For example, the area marked *Equilateral* contains triangle data which will be classified as being equilateral.

Most programmers will generate test data which lies at the centre of one of these areas. However, the most effective test data

guessing and equivalence partitioning in order to supplement this with data which is almost guaranteed to blow up the software under test.

It is worth stressing that the mix of data that is generated really depends on the problem. Some systems are heavily decision-based and a large amount of decision-table data should be generated. Other systems will generate a small amount of decision-table data and a lot of error-guessing data.

As a final example, consider the testing of a module

**FIND (a, n, x, t)**

which sets the variable t to one if the integer x is contained in the first n locations of the integer array a, otherwise clears it to 0. The maximum size of the array is 100 elements. The test data that I would generate for this problem is shown in Figure 4.

Note that error guessing data, such as character strings for numeric input, would not be used in this case as it is a test of a module. Instead they would be used if a whole system was being tested, especially one which required considerable interaction with the user.

And if all this generation of tables and study of results seems like too much bother, you know what to do. Go out and hire a psychotic.

**EXE**

## It's surprising how many errors are detected by a programmer explaining his own program

is generated near to the boundaries, or at the boundaries. Such test data will normally discover common errors such as a loop being executed one time too many or too few, or a < less than operator being used instead of a <= less than or equal to operator. That is why the test data 4,3,3, which tests for an isosceles triangle, is much more revealing than the test data 17,17,5 - it lies much nearer to the boundary of two areas.

## The best mix

To sum up, the best way to generate high quality test data is to use decision tables to generate an initial test set, then use error

*Darrell Ince is a Professor of Computing Science at the Open University. Until recently, he was acting head of the computing department.*

# At their breaking point

*Dan O'Brien and some source debuggers examine each other's mistakes.*

Debuggers are the big comfy chairs of programming. You buy one early on and use it all the time. Gradually, you become accustomed to its bumps and patches. Later in life, you find it impossible to get out of. Finally, it falls over, and you have to get a new one. A lot of PC debuggers, I suspect, have been falling over in the past year. Standards have changed: OOP's got its foot in, DOS extenders are two-a-penny and 386 coding is all the rage. Is it time to junk SYMDEB and move on?

The debuggers we have reviewed here work as stand-alone debuggers, and are sold as such. We decided early on to exclude programs only available as part of a high-level language package, or designed to support only one range of products. This missed some important contenders - the Zortech and TopSpeed debuggers are, despite their omission, perfectly worthy programs. No-one, however, is going to switch languages solely on a debugging recommendation. That said, we did include Soft-ICE's Bounds-Checker, a program some would deny status as a debugger at all. We felt, however, that it addressed in a novel way many problems that usually throw programmers into the arms of debuggers. We also excluded the big boys: the In-Circuit Emulators such as the Periscope IV. Impressive as they are, they are pricey and bear a sledgehammer/nut-like relationship to most DOS applications.

This left us with five products to pick over: Nu-Mega Technologies' Bounds-Checker and Soft-ICE, Microsoft's CodeView, Periscope I, and the Borland Turbo Debugger. All except Bounds-Checker have been around for some time, although all the companies have released new versions of their software in the last few weeks.

Fans of *Which?* magazine will recognise the 'more blobs the better' format of Figure 1. Following the Consumer Association further, we decided to test each debugger to

destruction. After all, one expectation of a debugger is that it shouldn't crash, even in the face of massive programming incompetence. So we set up each debugger to 'debug' the following uranium-laced suite: two programs that walked over the segment 0 interrupt vector table (one forwards, one backwards), two bug-ridden keyboard

---

***1991 will be an  
interesting time,  
as the Chinese  
curse has it***

---

interrupt TSRs, and one grimly determined infinite loop with all interrupts disabled and the NMI port constantly being accessed. Results of these tests, and other technical information, are stored in Figure 1's packed array.

## CodeView V3.10

We begin with the old boy. Microsoft CodeView, on its first release in 1986, set the standard for source code debuggers. It allowed simultaneous viewing of both low-level and high-level code, monitoring of variable changes, and simple to use trace and breakpoint features. It's gone through changes since then, but the commands, basic features and the familiar split-level (variables, source, command lines) display have remained constant.

Sadly, CodeView has suffered what the old American journals used to describe as 'bit decay': the strange affliction of code that turns fine software into an untidy morass within a few updates. This, together with what might be termed Spoilt Development

Team Syndrome, has meant that CodeView can now only realistically be run on a *damn* fast processor with a lot of spare RAM, disk space and, preferably, a second monitor (obligatory in CodeView for Windows). And even then it's a monster, as anyone who has found themselves raising small families during a CV reload will testify.

Nevertheless, CodeView still scores well at being a source-code debugger, in the strictest sense. If you dive no lower into PC arcana than using the occasional 'far' with your pointer definitions, CodeView will help (probably more than Soft-ICE and Periscope, which assume a fair degree of 80x86 savvy). Unfortunately, DOS bugs generally lie a level lower than that, in illegal pointer addressing and segment nightmares. Out of all the debuggers, CodeView crashed the most when faced with deeply errant code. This is forgivable, if one remembers that looking after interrupt vectors and TSR debugging isn't what CodeView was written for. CodeView was written to debug payroll packages, and sneer as much as you wish, it does that well.

CodeView also has the considerable advantage of being Microsoft and, therefore, court favourite. This provides several benefits. Other debuggers emulate it, so if you know how to use CodeView (despite window dressing, it's a command line beast), you'll know how to use any other debugger. If something happens in the Microsoft/Intel/IBM sphere, CodeView will be the debugger that will handle it first. And it's still the only Windows Enhanced source-code debugger.

Is it worth getting CodeView? Bought with MASM 5.0 in the stand-alone package, probably not: the two don't complement each other very well. If you're using a Microsoft language, you should have it already. If you have it and use it, and hate it, then don't worry: there are better packages.

## Soft-ICE V2.5

Soft-ICE will be a familiar product to regular readers: .EXE has reviewed it twice in the past. It's a 386 debugger that runs programs in a virtual 8086 box, allowing trickery usually associated with In-Circuit Emulators (hence the name). This includes breaking out of code with interrupts disabled, and the provision of sophisticated breakpoint facilities, including full speed breakpoints on memory read, and large (up to 4 GB) breakpoint ranges - useful for write protecting blocks of memory.

Virtual debugging is an exceptionally good way of isolating a debugger from madly thrashing code: unfortunately, it also means you can only debug real mode software. A possibly greater restriction is that you can't use it with other virtual handlers present - ruling out the use of Qualitas' 386MAX, QEMM or, for that matter, enhanced mode Windows 3.

Soft-ICE softens the blow by including a full (LIM 4.0) expanded memory manager in its kernel, and by allowing the loading of TSRs and device drivers into high memory. It is also vindicated by being an extremely good virtual debugger. Its emulation of a standard real mode system is excellent: even our other debuggers thought they were running under real mode. Intel's undocumented LOADALL function (see .EXE's passim) is fully emulated, as are the BIOS extended memory move operations. The new instructions of the 386 and 486 are fully supported.

Soft-ICE also won prizes for sheer resilience. Soft-ICE stood fast throughout the .EXE lunatic code, returning its prompt at all times. In fact, the only way we could get it to crash was by sneakily switching to protected mode - a move which Soft-ICE, fair enough, took great exception to. Overall, this compared very favourably indeed with our other debuggers, which failed at least one test (see table).

Soft-ICE principle drawback is that, like SYMDEB, it is primarily a machine-code debugger with source code extensions. It is also a little unfriendly, using DEBUG-style one letter commands, albeit with a status-line help. SYMDEB hackers will be mightily impressed, but CodeView users can expect to be disappointed with its lack of decent variable inspection features. Soft-ICE knows nothing of structures and you would certainly be hard pushed to follow a linked list using its simple memory dump. You *can* use CodeView and Soft-ICE together, but the twinned operation is convoluted and I shudder to think of the memory usage,

even if you do shove it all up into your extended RAM.

Soft-ICE, when it was first released, had no real competition. Its price of \$386 was a bargain. Now other debuggers are beginning to appear with the same features, Soft-ICE is losing its pre-eminence. Moreover, all Soft-ICE's advantages reflect its authors' in-depth knowledge of virtual machine

## *The simplicity of the concept belies Bound-Checker's usefulness*

mechanics: a protected mode version of Soft-ICE would have to be an entirely different beast to compete. Soft-ICE knows its limitations, and it is good at what it does: if you are developing standard DOS applications, and will do so for the foreseeable future, it's probably the toughest of the pack. If you're looking to move up to the fertile plains of protected mode operation, Soft-ICE will be just a pricey addition to your doorstep collection.

## Bounds-Checker V1.0

Along with our review copy of Soft-ICE came Bounds-Checker, Nu-Mega's new product. Bounds-Checker is not a debugger *per se*. Rather, Nu-Mega has used virtual debugger techniques to implement what is, in effect, an automated bug-finder. It works by closing off all of a 386 system's memory from your program, except for those areas which are explicitly decreed to be modifiable. This will usually be the program's data segments, but it could also be display memory, or unallocated RAM. Your program is then run under Bounds-Checker via a small stub loader. Now, any writes to (or reads from) outside these rigidly defined zones will be signalled, and the source code in which they occur can be noted in a file, or added to the exception list. Moreover, if there are any other rogue TSRs attacking your code, their illegal accesses can be tracked as well.

The simplicity of the concept belies Bounds-Checker's usefulness. I found Bounds-Checker to be an immensely handy program. Apart from discovering faults that would otherwise go entirely unheeded, it was useful as a prelude to de-

bugging, as it pin-pointed quickly where in the code matters were beginning to go wrong. Naturally, it spotted our interrupt vector bruisers before they began. It also prevented the buggy TSRs from doing any damage, and was instrumental in tracking down a couple of real live bugs which had been plaguing the .EXE office for some months (pride prevents us from revealing exactly how long).

This is a program that is easy to understand, easy to use (the Bounds-Checker logging system could be used by anyone, and a large section of the documentation explains exactly how one can delegate bug detection using the program) and, more important, productive. Being based on the same technology means that it suffers the same implementation restrictions as Soft-ICE, but as most of the bugs that Bounds-Checker could trap would be caught by a decent protected mode memory handler anyway, this is less of a restriction. A good implementation of an idea that has come not a moment too soon.

## Periscope I, Rev 3 V5.0

Periscope has a long history, as can be guessed by the number of version tags it sports. The early Periscope years were based on one product, a PC card pulled the NMI line low and kicked in Periscope's own source code monitor with one squeeze of a hand-held, rather Ian McCaskillish, break-out switch. This card's design has now reached its third revision, and now boasts 512 KB (expandable to 1 MB) of on-board memory for storing source and symbol information. The Periscope Company also produce a full ICE system, the Periscope IV, which plugs into the CPU socket and an ISA slot, and the Periscope II, a software version of Periscope I (with optional switch tied straight to the NMI line).

Periscope I's great advantage is that it can work on any system, from the humblest XT up. The card adapts, ingeniously, to an eight or 16-bit slot, and the software will work with all its clever bits on any processor. I had no problems, for example, in running the system on an old Compaq 286; not the most traditional of PC set-ups. All this means that it is ideal for on-the-fly (and in-the-field) compatibility problems. Its hardware roots also mean that it is a fine choice for ISA cards and DMA development. The many commendations we received on CIX for the Periscope system came from hardware developers who found it the only debugger they could use.

The Periscope I software resides in the fag end of the first megabyte, past 640 KB. The

software itself smacked of slapdash programming. A pull-down menu system and built-in help failed to hide an old and unfriendly front-end. As expected from an NMI-driven debugger, it toughed out a number of tricky situations, as our tests show, but in general use had a tendency to crash without obvious reason. Extra features like 386 debugging support, key redefinitions, and data structure inspection seemed like awkward bolt-ons, although Windows real mode support was good (and unique out of the debuggers reviewed). My overall impression was of well-designed hardware let down by software support. The Periscope program also shows a touch of Spoilt Developers Syndrome itself, with most of my discovered bugs coming under the category of 'that wouldn't happen if you were using a Periscope IV with Secondary Monitor'.

In fact, the Periscope I is treated throughout the documentation and software as the little brother of Periscope IV. Some features, for example, that wouldn't be impossible to emulate in software on a 386 hosted Periscope I (like pass counters and selective capture for tracing) have ended up on Periscope IV only. Given that other debuggers manage some of these tricks and don't cost as much as Periscope I, let alone Periscope IV's £1000+ price tag, this does seem a smidgeon foolish. On the other hand, Periscope have been excellent at updating and modernising their systems in the past, and a plethora of 'Real Soon Nows' in the documentation may mean that Periscope I's paucity won't last long. Certainly, the Periscope system doesn't face the protected mode ceiling of a program like Soft-ICE. I'm just not sure, given the current evidence and the temptations of their full ICE system,

how much attention Periscope will give to its first born.

## Turbo Debugger V2.01

Turbo Debugger is Borland's house replacement for CodeView. It did not begin its tour of duty at .EXE well. For one thing, Turbo Debugger has a fully WIMPed interface, with overlapping windows and all that. Now, if there is one area (screams the Luddite in me) where command lines still have a rôle, it's in a debugger. First, because command line histories do, at least, give an easily stored record of the debugging session, which is something that 'state of the machine' windows and mouse-based commands cannot easily achieve. And second, after three months of typing up code, most people aren't afraid to do a little 40 wpm in order to throw up a hex dump. Mousing through a desk full of empty coffee cups is an irritation, not an aid to accessibility.

I suspended judgement and moved onto our crash and burn tests. On my first run of the Interrupt Vector Stomper, I had to stop and re-check my code. Surely Turbo couldn't have crashed *that* soon? Somehow, it had managed to snarl itself on a corruption of interrupt vector 0xFC, just four vectors into the test. Even CodeView can handle corruptions down to INT 0x6D. A closer look at the code, and much later Turbo Debugger's manual revealed the problem: Turbo Debugger only preserves interrupts from 0x2F down, on the assumption that this will be 'okay'. And so it will, unless (for example) you run KEY-BUK.COM, the old DOS 2 English keyboard handler, a TSR which re-calls itself through higher (INT 0xFC) interrupt vectors. In fact, Turbo Debugger wasn't very good on interrupt based TSRs at all, crashing under all those I tried to debug. A shame, particularly as tracing through TSRs is exactly what people want stand-alone debuggers for.

Further confirmation of my pessimism came when I tried programs created on non-Borland compilers. The Turbo range possess their own debug format, which Turbo Debugger naturally supports, so CodeView-compatible .EXE files have to be converted using a small, supplied utility. Alas, TDCONVRT.COM is not much cop: it's slow, and doesn't always work. It misunderstands comment records, for instance, which makes it fail on many Zortech compiled programs.

Despite all these problems, Turbo Debugger did, in the end, win me over. The reason for this is a feature not greatly documented by Borland - one chapter in the

Name:	CV	SI	BC	TD	PE
Version	3.10	2.5	1.00	2.01	5.0
Price	£99	\$386	\$249	£105	£355
Processors: (8086, 286, 386, 486)	0234	34	34	0234	0234
Hardware/Software/Virtual	Soft	Virt	Virt	S&V	Hard
<b>Interface</b>					
WIMP?	Part	No	No	Yes	Part
Mouse support?	Yes	No	No	Yes	No
Ease of Use	●	●●●	●●●●	●●●●	●●
Disc use?	Lots	None	Small	Small	None
Documentation	●●●	●●●●	●●●●	●●●●	●●●
Redefinable function-keys?	No	Yes	No	No	Yes
Secondary monitor?	Yes	Yes	Yes	Yes	Yes
Dumb terminal?	No	Yes	No	No	No
Alternative PC?[2]	Yes	No	No	Yes	Yes
<b>Features</b>					
Source breakpoints	Yes	Yes	-	Yes	Yes
Assembler breakpoints[1]	Yes	xrw	-	xrw	XRW
Breakpoint ranges	No	Yes	Yes	Yes [6]	Yes
Variable inspection	●●●●	●●	-	●●●●●	●●●
Stack inspection	●●●	●●	-	●●●	●
Backtracing	●●	●●●	-	●●●	●●
Debugging EMM programs	●●	●●●	-	●●●	●●●●
Debugging TSRs/Device drivers	●	●●●●	-	●	●●●
CLI loop test?	No	Yes	-	Yes[6]	Yes
Interrupt vector destruction test?	●●	●●●●●	-	●	●●
Extended memory use	Can	Can	Can	Can	Can
Expanded memory use	Can	Can	Can	Can	Can
<b>Compatibility</b>					
Linker support: (MS,TLINK,RTLINK,PLINK)	M	M,T,R	M,T,R	M,T	M,T,R,P
Can work with: (CodeView,SoftIce,Periscope,Turbo)	S,P	C,P,T	S	S,P	C,S,T
Can pick debug information from .MAP?	No	Yes	Yes	No	Yes
Easy to move from: (CodeView, Turbo, SYMDEB)	S	S,T,C	-	C	S,C,T
Object oriented browser?	G[3]	No	-	T	No
Name unmangling?					
Zortech,Glock,Turbo	ZG[4]	ZG[4]	-	ZG[4]T	ZG[4]
<b>The Future[7]</b>					
OS/2?	Yes	No	-	?	Yes
Protected?	Yes	No	-	RSN	RSN
Windows?	Yes	?	-	RSN	Yes[5]

[1]

xrw - Execute-only, Read-only and Write-only breakpoints on 386.

XRW - Execute-only, Read-only and Write-only breakpoints on all machines.

[2] Alternative PCs have a full screen display; dumb terminal support is just an ASCII serial link.

[3] With Glockenspiel PWB support package.

[4] With Cfront name unmangler.

[5] Real mode ONLY.

[6] TD386 only.

[7] RSN = Real Soon Now.

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back of the manual. This is a 386 version of Turbo Debugger included on the disk that reveals itself, on closer inspection, to be a full virtual mode debugger.

TD386 as it is, stands above all the other debuggers reviewed. In CodeView, 386 enhancements are practically non-existent. Soft-ICE does it all well, but falls down on source support and ease of use. Periscope can do 386ish things on other processors, but skimps using the proper on-chip facilities when running on a 386 system. Turbo Debugger, on the other hand, implements it all, and well. The 386 usage is entirely invisible to anyone used to Turbo Debugger: except that suddenly they can write-protect 100 KB of memory, or watch variables while running at full speed, or watch for pokes into code.

Together with Turbo's excellent implementation of what CodeView fouls up (good variable inspection and excellent backtracking), its low-level code support, its built-in OOP class browser, and (on 286/386 systems) its high-loading facility, Turbo Debugger comes closest in our selection to what one should *expect* a modern debugger to do. Nevertheless, while the

bugs we found weren't ruinous, they did shake one's faith in the product as a whole.

## Conclusions

There's a great deal of competition in the debugging market, and these five products cover a lot of ground. If you want, you should be able to pick one that will satisfy your requirements. If your debugging life consists mainly of COBOL-like manoeuvres, CodeView is probably the best bet. If you want a safe, reliable debugger for TSR and other low-level DOS work, Soft-ICE seems a better choice. Periscope I lends itself to work that requires testing on a number of systems, or if you are debugging hardware developments. Turbo Debugger is an excellent debugger for Borland products, although given its problems I'm somewhat reluctant to recommend it whole-heartedly for general use. Bounds-Checker will, I imagine, generate its own market: I would most definitely recommend it for use on products meant for general PC consumption.

My difficulty lies in foreseeing a long lifespan for these products. 1991 is going to be a very interesting time, as the Chinese curse

goes, for PC software developers, and the fact that none of these debuggers (apart from the behemoth CodeView) support Windows 3 enhanced must be seen as a severe limitation. Several companies, including Zortech and Multiscope, are due to release protected mode debuggers within the couple of months. Out of the five products, I would say only Bounds-Checker and possibly Turbo Debugger have adapted to the changes in the last year or so; the remainder are rather resting on their laurels. The competition, as I've said, is already high in the debugger market: expect it to get a lot worse, soon. If you're not desperate for a new debugger right now, I'd stick with SYMDEB a little while longer, and wait for the New Year sales.

EXE

*Prices for CodeView and Turbo Debugger were taken from Grey Matter's price list. Soft-ICE and Bounds-Checker are available direct from Nu-Mega Technologies, PO Box 7607, Nashua, NH 03060-707, USA. (Tel: 0101 603 888 2465). The Periscope range is available from Roundhill Systems, at Orchard House, Ogbourne St George, Marlborough, Wiltshire SN8 1SU.*

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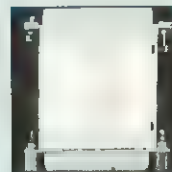


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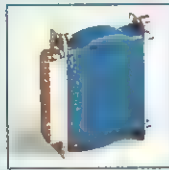
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# Gathering program statistics with C++

*Talk of OOP invokes the image of towering class hierarchies and teaming virtual methods. Yet there are some good straightforward applications, as Bryan Boreham explains.*

The code presented in this article contains no inheritance and no dynamic binding, which is a bit unusual for a piece on object oriented programming. However, it does demonstrate one way in which C++ can help to improve and structure your programs using a few new language features, but without requiring you to dive straight in and rewrite everything as objects. Let me tell you how it all began...

Some time ago, I was in the process of optimising the data storage code for a large C++ project. The objects were all retrieved via standard SQL from a relational database, and so it was important to try to reduce the number of database accesses being performed. So, I declared variables to count how many operations (retrievals, updates, deletes etc) were done, and more counters to try to discover what areas these came from.

```
#include <string.h>

void isort(char **a, int n)
{
    char *p;
    int i, j;
    for (i = 0; i < n; i++)
    {
        p = a[i];
        for (j = i-1; j >= 0; j--)
        {
            if (strcmp(p, a[j]) > 0)
                break;
            a[j+1] = a[j];
        }
        a[j+1] = p;
    }
}
```

Figure 1 - C implementation of insertion-sort

Each time I added a new counter, I would have to define it in the database module, then declare it as `extern` in the main program, where I needed a `printf()` to output the counter's final value at the end of the program. The whole business started to look a bit naff, and I had to recompile two modules for each iteration (not as trivial as it sounds, with the amount of `#include` files our project used). I set out to solve the problem in a neater way by using C++'s ability to extend the language by creating new types with special properties.

## The problem

Since the system that sparked this development is so large, it would take several issues of .EXE to print the listing, I shall take, as an example, a small insertion-sort routine that takes as arguments an array of zero-terminated character strings and an integer giving the number of strings in the array (Figure 1).

This article is not about sorting, so I shall say very little about the algorithm: basically in the inner loop, array elements are moved downwards in the array until they reach the correct position, and so the array is sorted from 0 to `i` each time round the outer loop. This is not supposed to be the most efficient sorting routine in the world, or even the best implementation of insertion-sort, so please don't write in on that score.

(Incidentally, all listings have been compiled and tested with the Zortech V2.1 and GNU V1.37 C++ compilers, so they should work for you.)

Suppose we wanted to count how many comparisons were made during a sort, and

how many times data elements were moved. This information would be useful in deciding upon the correct data structure,

```
#include <string.h>
#include <stdio.h>

#ifdef NDEBBUG
#define INC(x)
#else
#define INC(x) x++
#endif

void isort(char **a, int n)
{
    int n_cmp = 0, n_ass = 0;

    char *p;
    int i, j;
    for (i = 0; i < n; i++)
    {
        INC(n_ass);
        p = a[i];
        for (j = i-1; j >= 0; j--)
        {
            INC(n_cmp);
            if (strcmp(p, a[j]) > 0)
                break;
            INC(n_ass);
            a[j+1] = a[j];
        }
        INC(n_ass);
        a[j+1] = p;
    }

#ifdef NDEBBUG
    printf("No of assignments:\n%ld\n", n_ass);
    printf("No of comparisons:\n%ld\n", n_cmp);
#endif
}
```

Figure 2 - Sort routine with code to gather statistics

```

#include <stdio.h>

class Statistic
{
    const char *name;
    int count;
public:
    Statistic(const char*);
    ~Statistic();
    void operator++();
};

inline Statistic::Statistic(const char *n)
{
    name = n;
    count = 0;
}

inline void Statistic::operator++()
#ifdef NDEBUG
{
}
#else
{ count++; }
#endif

inline Statistic::~~Statistic()
{
#ifdef NDEBUG
    printf ("%s: %d\n", name, count);
#endif
}

```

*Figure 3 - Complete implementation of class statistics*

algorithm, access mechanism and so on in a larger system.

## Doing it in C

The first implementation to gather these program statistics stays with pure C, and defines two counters `n_cmp` and `n_ass`. A macro `INC()` is defined so that the counting code can be taken out when building a production version of the program. The symbol `NDEBUG` is used quite often (eg in the ANSI standard include file `ASSERT.H`) to tell the compiler whether or not to include debugging code, and so I have followed normal practice here. When debugging is complete, use the compiler flag `-DNDEBUG` to define the symbol and hence remove all overhead. Figure 2 shows the reworked version.

Consider some of the problems associated with this implementation. As mentioned earlier, for each new count, I have to define it at the top of the function, and also add a `printf()` to output the result. If I am gathering data in several functions across the whole run of a program, this `printf()` will have to go at the end of `main()`, which is probably in a different file altogether.

Suppose we discover that `int` isn't big enough on a particular machine to hold the count, so we decide to use `long` instead. Then all the declarations and `printf()` references have to be altered and, of course, it is extremely easy to forget to change one of the `printf()`s because no type-checking is done on its format string arguments.

Maybe later we will decide to ship beta-test versions of the system including the statistic-gathering code, and log the data in a file. All of the `printf()`s will have to be changed, and code must be added to open and close the log file each time data is output.

All of these problems stem from the fact that the implementation of our counters is totally exposed, and this is what happens all too often when you hack something up quickly to do some small task. Quick hacks can remain in the code for years, causing problems when the system has to be maintained or enhanced.

C offers a few data-hiding features: we can use a `typedef` instead of `int` for the counter variables, so that the actual type can be easily altered, and we can declare a function in another module to do the data output. However, with C++ we can declare a whole new type to add to the language, which makes the whole thing much neater and simpler.

## Class Statistic

Figure 3 shows a class `Statistic`, which I developed over a few days during the optimisation exercise mentioned earlier. The various facilities were extended and then refined in use, and I ended up with what you see here.

The constructor takes as an argument the name of each `Statistic` and zeros the count. The name is remembered for later,

as it is used in the destructor.

The `++` operator is defined for objects of class `Statistic`, incrementing the count, but no other arithmetic can be done with them; in particular it is impossible to zero the count accidentally.

As an improvement on the `INC()` macro in the C solution, `operator++` is defined as an inline member function, with two possible implementations. Just as before, we use `NDEBUG` to differentiate between them: if `NDEBUG` is defined, no code will be generated when `++` is applied to an object of class `Statistic`. In this way, we restrict the ugly `#ifdef` code to a single point, we avoid the introduction of another identifier, and we get to use the traditional C syntax for incrementing without compromising on efficiency.

The really clever bit is that the destructor is given the task of outputting the name and final count. This means that the data will be output when a `Statistic` goes out of scope, and so all we have to do in the insertion-sort example is to declare a couple of `Statistics` at the top of the block, and we get the printout automatically when the function returns.

To gather data over a whole program run, declare `Statistics` with file scope, so that they will get destroyed after the program exits. In this way, we can avoid putting code into `main()` to output the counts. Note that there is a subtle portability problem here: C++ does not specify the

```

#include <string.h>
#include "statistic.h"

void isort(char **a, int n)
{
    Statistic n_cmp("Number of comparisons");
    Statistic n_ass("Number of assignments");

    char *p;
    int i, j;
    for (i = 0; i < n; i++)
    {
        n_ass++;
        p = a[i];
        for (j = i-1; j >= 0; j--)
        {
            n_cmp++;
            if (strcmp(p, a[j]) > 0)
                break;
            n_ass++;
            a[j+1] = a[j];
        }
        n_ass++;
        a[j+1] = p;
    }
}

```

*Figure 4 - Sort routine using statistic objects*

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CIRCLE NO. 433

order in which destructors from different modules get called, and so we cannot use 'cout <<' in the `Statistic` destructor for fear that `cout` will have been destroyed before the `Statistic` object.

I have declared all members of `Statistic` inline, so that you can type it into a file `STATISTC.H`, include that in your C++ programs and start to use it immediately, but the destructor should probably be coded out-of-line in a separately compiled C++ file which you link with your system. Then, the exact format in which the count is output, whether it goes to `stdout`, `stderr`, a log file or whatever, can be changed without recompiling the places where `Statistics` are used.

It is, in general, good C++ programming practice to define inline methods outside the class declaration, so that they can be easily moved into their own module if appropriate. The alternative, putting the code beside the methods inside the class declaration, requires extra editing if you decide to make such a change, and can make the code harder to read.

## *The design benefits from C++'s principle of 'you don't pay for what you don't use'*

### Conclusion

If you take a look at Figure 4, you will see that our sort routine now looks a lot neater. Surely no argument that this is a big improvement.

Much of the power of OOP stems from encapsulation: each program element is defined and used in terms of a public interface, while the actual data and implementation that it uses are hidden, and can be changed without affecting the rest of the

system. I hope that even this short example can show how useful and simplifying encapsulation can be within any programming project.

In C++, constructors and destructors are primarily intended for initialisation and clean-up of objects, but as you can see they can offer a powerful new programming mechanism too. It is even possible to have a class do useful work with no member functions other than a constructor and destructor!

As I said, there is no dynamic binding and no inheritance in this article. Nonetheless, my `Statistics` clearly are objects, and the fact that they do not suffer any virtual function overhead when used is merely a win for C++'s principle of 'you don't pay for what you don't use'.

[EXE]

*Bryan Boreham is an experienced C++ programmer, who took part in the .EXE 'round table' session with Bjarne Stroustrup. He lives in Middlesex.*

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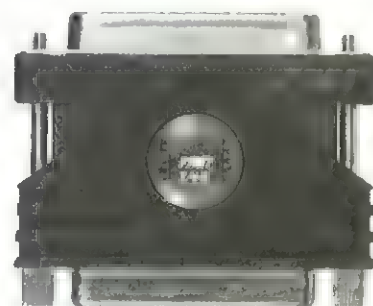
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# Six Trix

*Paul G Smith and Will Watts take a look at Borland's new wonder product, Turbo Pascal V6.0, which includes an object-oriented applications framework called Turbo Vision.*

Since Borland took its first step into the world of Object Oriented Programming with Turbo Pascal V5.5 in the summer of 1989, it has been keen to promote the idea that it excels in OOP technologies. This spring saw the launch of Turbo C++. On the 5th November 1990, Borland launched Turbo Pascal V6.0, the first PC product to include an object-oriented applications development framework.

This article should be thought of as a product preview, rather than a formal or comparative review, because the first copies of Turbo Pascal V6.0 arrived in the UK only a couple of weeks before the deadline for this issue. We looked at version 6.0 of the Turbo Pascal Professional package. Turbo Pascal has been around since 1983, when Borland first introduced its aggressively priced \$49.95 product.

Although Turbo Pascal 5.5's version number suggests that it was an intermediate release of the product, there were more changes to the Turbo Pascal language between V5.0 and V5.5 than between V5.5 and V6.0. The significance of V6.0 is in the rest of the package.

For a start, there is a completely new integrated program development environment (Borland habitually uses the acronym 'IDE'). There is an updated version of the Turbo Pascal compiler, linker and integrated debugger. The documentation has

been revised. If you buy the Professional edition of the product you also get the Turbo Assembler, Turbo Debugger and Turbo Profiler. (NB These latter items are not described in this article; but see *At their breaking point* elsewhere in this issue, for an assessment of Turbo Debugger. Figure 3 shows Turbo Debugger's very impressive class navigation facility.)

The compiler has a few revisions, including

generic text-window application you can use to build professional quality deliverable programs using object oriented programming techniques. A lot more on Turbo Vision later.

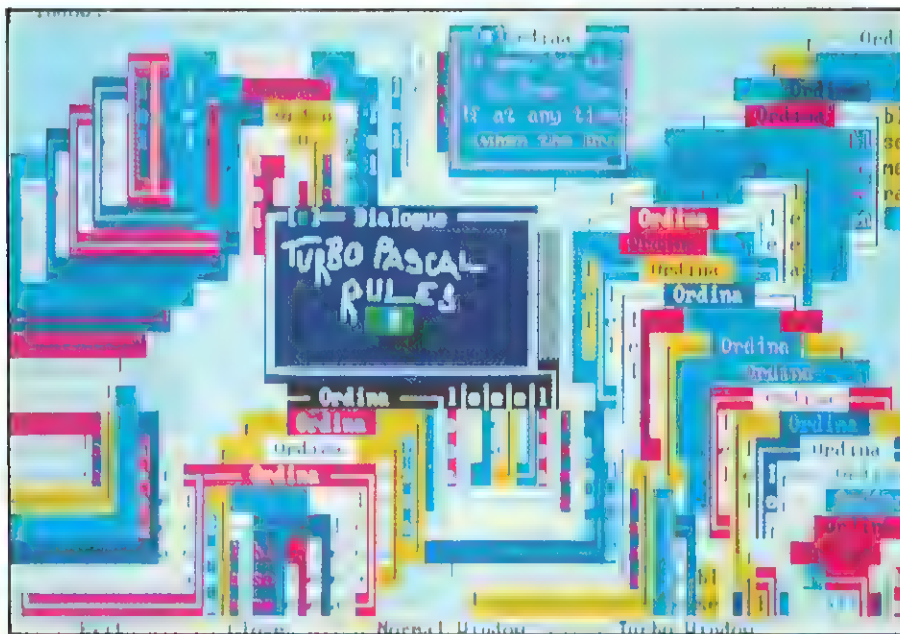
## The IDE of Turbo

Borland has offered some sort of integrated programming environment for Turbo Pascal since V1.0 in 1983. Today's offering is a lot more substantial, and will be familiar to users of Turbo C++. The IDE creates an environment within which you can write, compile, link and debug programs. It is very nice to work with, having a well designed user interface and consistent operational rules. Let's take a closer look. (Please refer to Figures 1 and 2 for pictures of the IDE in operation.)

When you launch the IDE, you are taken into a text-only world of windows, pull-down

menus, and mouse and keyboard operation (you can use the keyboard to control windows and use menus if you don't have, or don't want to use, a mouse. However, in the opinion of WRW, the design favours mouse users to the disadvantage of keyboard-only users). Across the top of the screen is a menu bar containing System, File, Edit, Search, Run, Compile, Debug, Options, Window and Help menus. At the bottom of the screen is a status line, which also displays function key assignments. In between is the area in which the editing windows,

Included with every copy of Turbo Pascal V6.0 is the Turbo Vision framework, a



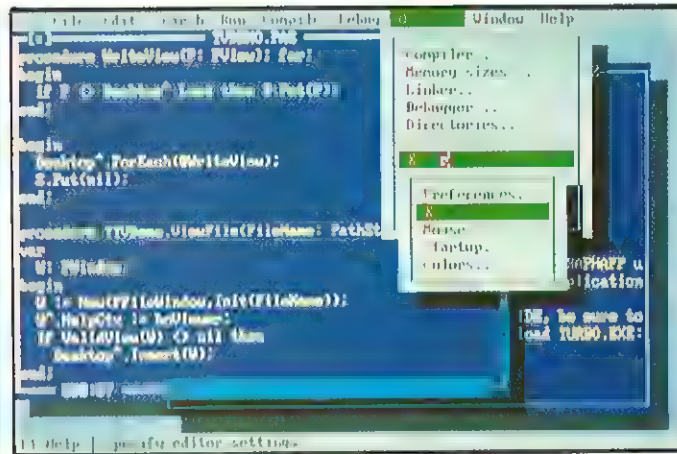


Figure 2 - The IDE's Options menu

change as your program executes), and manage breakpoints.

The Windows menu controls the position and layout of windows, letting the non-mouse user do window positioning and resizing. It also has commands that open a 'call stack' window (that can be used to trace how your program reached the currently executing procedure) and toggle between seeing your program's output in an IDE window and letting your program use the entire screen.

The Help menu manages the IDE's built-in context-sensitive help subsystem. Help is included on most of the IDE and Turbo Pascal. You can navigate downwards from a table of contents, or search for help on the item in the edit window that is under the cursor. The help text is thoroughly cross-referenced (as usual with hypertext schemes, a cross-referenced item appears highlighted in the text. Clicking on the item takes you to the relevant page).

The IDE is highly configurable, through the Options menu, through various command line options at start-up and through TEML, the Turbo Editor Macro Language. The Options menu gives you access to many configuration dialog boxes including compiler, linker and debugger setup (it is here that you choose whether to use the integrated debugger or the Turbo Debugger). It also has dialog boxes for default directories, environment settings including editor, mouse and general preferences, and also screen colour assignments. You can save and restore options settings on disk.

File View Run breakpoint: Data Options Window Help

Object Hierarchy

TUTORIAL	THENIMAR
TORTISTHROWWINDOW	THENIMOX
THACKGROUND	TGROUP
THIRSTREAM	THESKTOP
TBUTTON	TPROGRAM
TCHECKBOXES	THAPPLICATION
TCLUS	THAPP
TCDL	THWINDOW
TCDL NEXT : TPUTW	THRECTTYPEHROWWINDOW
TCDL TUIW ORIGIN : TPOINT	THRTINSTHROWWINDOW
TCDL TUIW SIZE : TPOINT	THLABELHROWWINDOW
TCDL	THIMMWINDOW
TCDL PROCEDURE TONHIT FREQ	THITLROWWINDOW
THESK VIRTUAL DESTROY FOR PROCEDURE TAPP	THISTORYWINDOW
TOTAL VIRTUAL PROCEDURE TUIW TALK BOUND	THIALOG
TPOSS VIRTUAL PROCEDURE TGROUP CHANGERO	THORRIALOG
THIMM	THOLBAR
THESKTOP	THIT TOWER
THFRAME	THCOLORSAMPLAT
THORUP	THCOLORITEMST
THITORY	THIT TOWER

HELP

TUTORIAL

THRECTTYPEHROWWINDOW

THRTINSTHROWWINDOW

THLABELHROWWINDOW

THIMMWINDOW

THITLROWWINDOW

THISTORYWINDOW

THIALOG

THORRIALOG

THOLBAR

THIT TOWER

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```

type
  cursor = object (graphicObject)
    procedure draw;
    procedure moveTo
      (hPos, vPos: INTEGER);
  private
    hLoc:    INTEGER;
    vLoc:    INTEGER;
    overlay: BitMap;
    mask:    BitMap;
    procedure changeCursor
      (overlay, mask: BitMap);
  end; {cursor}

```

Figure 4 - Using the 'private' keyword

have to pass a prepared script through a special compiler to produce a configuration file which the IDE sucks in at start-up. You can use it to force the IDE to respond to the same keystrokes as the editor you were brought up on as a child, or, if you get ambitious, you can set up fancy macros which generate procedure templates.

To get the best out of the IDE you will want to fine tune the configuration. The default is not necessarily the best for your system, especially if you want to make good use of extended memory. Paul had to adjust the configuration to take full advantage of his 33 MHz 386 machine's 4 MB of extended memory. Even so, he was still occasionally tight on memory. One program that he ported to Turbo Pascal V6.0 could never be built inside the IDE - we had to use the command-line compiler. This isn't a serious criticism, though: the IDE is capable of dealing with all but the largest projects and the limitations are those of real-mode PC operation.

```

procedure PrintDecimal
  (Decimal : Word);
{ Recursive procedure,
  prints parameter as a decimal }
label
  PrintIt;
var
  NewDecimal : Word;
begin
  asm
    mov dx, Decimal
    cmp dx, 10
    jb  PrintIt
    mov ax, dx
    xor dx, dx
    mov cx, 10
    div cx
    mov NewDecimal, ax
    push dx
  end; { asm }
  PrintDecimal (NewDecimal);
  asm
    pop dx
  end;
  PrintIt:
    add dl, '0'
    mov ah, 2
    int $21
  end; { asm }
end;

```

Figure 5 - Using the Inline assembler

When you do start to push the barriers of what can be done inside the IDE, you can use the command-line versions of the Turbo Pascal compiler and linker. Borland provides two: TPC.EXE operates in 8086 real mode, TPCX.EXE (in the Professional edition only) operates in protected mode on 80286 (or better) based machines. Both of these compilers let you compile larger programs than is possible under the IDE. The latter, which uses a bought-in DOS extender quaintly called 'Turbo Driven' can compile extremely large programs, provided you have at least 1 MB of extended memory.

## Language changes

There are few changes to the Turbo Pascal language in version 6.0. The most important is the addition of a reserved word that allows fields and methods of classes to be defined as `private`, rather like C++ does. A private field or method is one that can only be referred to inside the unit within which the object type is declared. An example of the syntax is shown in Figure 4.

New to version 6.0 is the compiler's ability to generate (real mode) 80286 code. If the `$G+` compiler directive is set, the compiler makes use of some additional 80286-specific machine code instructions (such as `ENTER`, `LEAVE`, `PUSH <immediate>` and extended `IMUL` and shift operations) to improve the generated code.

The `$X+` directive enables 'extended syntax', which turns out to be the ability to ignore the return from functions. Previously, if you wished to stop the program until the operator pressed a key, you had to write

```

WriteLn('Press a key...');
dummy := ReadKey;

```

and discard the contents of `dummy`. Under extended syntax, you just say

```
ReadKey;
```

by itself, and the incoming keystroke is automatically flushed down the bit bucket. C programmers, who have always been able to do this anyway, will wonder what the fuss is about. Incidentally, when we spoke to Borland US's David Intersimone about this new release, he hinted that this directive was closely tied up with the way that the Turbo Pascal language was going to evolve.

The inline assembler, mentioned earlier on, is invoked with the `asm` keyword. An example of its use is given in Figure 5. As you can see, you may mix Pascal to Assembly language as much as you like. Writing the fragment in Figure 5, we couldn't be bothered to investigate TP's calling conventions, so we simply wrote the procedure's call to itself in Pascal.

```

program Simple;

uses App;

var
  MyApp: TApplication;

begin
  MyApp.Init;
  MyApp.Run;
  MyApp.Done;
end.

```

Figure 6 - The simplest Turbo Vision program

For those of you who enjoy pain, the old machine code `inline` statement is still supported. Note that Turbo Pascal V6.0 is syntactically entirely upwards-compatible with V5.5: all your old stuff should recompile straight off. However, as is traditional between consecutive releases of dear old TP, the format of the binaries has been tweaked; so if you rely on third party TPUs and you don't have the source, then you're stuffed pending an upgrade. However, it is our contention that you will, in any case, be junking all your user-interface libraries.

Overlays, that other favourite target of inter-version alteration, have been changed, but fairly minimally (the algorithm which controls the heap manager has been altered). References to `FreeMin` must be deleted, and those that depend upon `FreePtr` will need updating. Unlike C++ users, Pascal people have not been granted `VROOM` overlays.

## Turbo Vision

So, at last, to the best bit of Turbo Pascal V6.0. It is called Turbo Vision, and it is a really excellent object oriented application framework. What's so special about it? Hard to explain in a few words. Turbo Vision contains the framework of a complete text-windows applications package, including building blocks for important components. Imagine an integrated set of libraries to implement a text-mode version of Microsoft Windows - containing all the stuff to draw windows, track mouse movements, channel events, work out which window is 'on top' and so on - and you are not too far from the mark.

The Turbo Vision 'generic application' already knows how to load itself, present a text-windows mouse and keyboard event-driven user interface, store information on disk and so on: everything, in fact, except the application-specific functionality that is unique to your own projects. To create new applications, you simply subclass and selectively override the Turbo Vision classes: using object oriented programming tech-

niques there is no need to modify source code as one often has to with traditional user interface libraries. The simplest Turbo Vision application is just a few lines long (see Figure 6). This does nothing except present the standardised Turbo Vision user interface (an empty menu bar on the top line, 23 lines of 'breeze block' space characters and a status line with Alt-X Exit written on it). For a more impressive example of what can be done with Turbo Vision, you need look no further than the IDE itself.

All Turbo Vision objects belong to the object hierarchy shown in Figure 7. A dialog box (TDialog) is a type of window (TWindow) which is a type of group (TGroup - anything which can contain other displayable objects) which is a type of view (TView, a displayable object) which is a type of object (TObject - the generic Turbo Vision base object). Here are the OOP rules of design abstraction neatly played out.

How easy is it to use? Figure 8 shows some code, plucked from one of the numerous examples, to set up a menu bar with a couple of drop down menus. As a choice of example code, this is a bit naughty because at first glance it looks like hell. At second glance, and given the extra knowledge that Turbo Vision menus are constructed as linked lists, that NewItem returns a pointer to the menu item it has just created and is passed the list it is building on as its last parameter, it begins to come into focus. The main problem with Turbo Vision is that you have to learn the behaviour and names of a lot of objects before you can get into it (but not nearly as many as for something like Windows). This learning process is sped along by the excellent documentation, both printed and online. Once you have cleared this initial hurdle, writing Turbo Vision applications is a delight.

## Be Persistent

Objects may be a great programming convenience, but, with their multiple components, they are a terrible bother to set up, read/write to disk and so on. To combat this, Borland has developed a system of *persistent objects*. All classes derived from the base class TObject (which includes all of Turbo Vision types) can be made to work with *streams*. A stream is like a random access file; but you can store and retrieve *mixed* object types in it. A system of registration enables the mechanism to 'know' the type of an object as it is retrieved. In order to make your own object type 'streamable', all you need do is override a couple of methods, Load and Store, to handle your instance data, and register the

## The Apple inheritance

Turbo Vision owes a great deal to Apple's MacApp applications framework. Like Turbo Vision, MacApp has a hierarchy of objects descending from the base class TObject, including classes like TView, TApplication and so on. However, Turbo Vision is by no means a direct copy of MacApp: Borland has made a number of distinct design decisions and ended up with a product quite its own.

Apple started working on the predecessor of MacApp in the early 1980s, as a part of the Lisa project. They implemented a language called 'Clascal' (Pascal with classes) and wrote an applications framework on top of it. In common with MacApp and Turbo Vision, the Lisa Toolkit implemented a generic application that contained most of the user interface and data management functions shared by event-driven graphical user interface applications. Using object oriented programming techniques this could easily be extended to take care of applications-specific functionality. In 1983 Apple released the Object Pascal report, and started work on a rewrite of the Lisa Toolkit called MacApp. MacApp is now in its second major release, having been available for five years to Apple software developers, and has been used as the foundation of a great many successful software products. It is one of the most popular applications frameworks, and has been the inspiration of other class libraries like the Think Class Library and ETH Zurich's ET++ for C++.

There are a great many parallels between MacApp and Turbo Vision. Both are intended to implement the framework and core functionality of an application that implements a standardised user interface in a windowing mouse and keyboard event-driven environment. The underlying program structures (and many of the class names!) are quite similar, and it is clear that Borland took a good look at MacApp before they set off to invent their own product. For instance, Apple has a TEvtHandler class, responsible for receiving and dispatching events, from which are descended classes like TApplication and TView; Borland has made its TView class equivalent to Apple's TEvtHandler. Turbo Vision is a good deal less complicated than MacApp, though, which makes it a lot easier to learn and work with. A good deal of this is down to the fact that Turbo Vision supports a text-mode user interface, whereas MacApp has to deal with all the complications of the Macintosh Toolbox API and the Macintosh graphical environment.

More than once, at seminars and conferences, I have heard Borland staff talk condescendingly about Apple's 'early research efforts' into object oriented programming techniques using Object Pascal. It's interesting that nowhere in the Borland documentation or launch information do they refer to the debt they owe to Apple: this is one inheritance that shouldn't be forgotten.

object. This is a very useful and important feature, but there is not enough space here to cover it in any depth. Here is a good example of its use: when you start it up, the IDE reloads the desktop, complete with all its windows and views that you had at the end of the last session. Using streams, this can be accomplished in about five lines of code.

Turbo Vision also offers collection classes, for easy handling of multiple instances of objects, and *resources*, which are streams plus a simple database key system which allows you to retrieve objects using unique string references.

## Documentation

Turbo Pascal V6.0 comes with four perfect bound manuals: *User's Guide*, *Programmer's Guide*, *Turbo Vision Guide* and *Library Reference* (Borland wishes to draw attention to the fact that these have been

specially reinforced so, unlike previous offerings, it is possible to open them flat without breaking their spines). The User's Guide contains introductions to the IDE and the Pascal Language. The Programmer's Guide contains the definition of the Turbo Pascal language and various miscellaneous reference material, such as how to use the assembler. The Library Reference documents all the conventional (ie non-class) library material, including BGI - the Borland Graphics system. The Turbo Vision Guide contains both the tutorial and reference material for Turbo Vision. As is usual with Borland, the standard of documentation is high - the material is well-presented and easy to understand. Here and there a few errors have crept in (some are picked up in the README file), but nothing seriously amiss. One complaint: the write-up on some of the extra utilities (for example: MAKE and the IDE's script language) has been banished from the manuals to text files on disk. Surely MAKE is sufficiently

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important to merit proper documentation?

The online documentation is nearly excellent (this is high praise indeed from Will the Hypertext Hater), especially in its coverage of Turbo Vision. For example: each description of a class contains a diagram showing its position in the Turbo Vision hierarchy. Our complaints, which could easily be fixed, are 1) that there are a few rough edges in the hypertext links, for example: you cannot directly discover, given the name of one Turbo Vision constant, in which TPU is declared; and 2) there is no way of performing a linear search for a text string across the whole database.

Convention dictates that something must be said about installation. It's very easy and sensible, and the only trick that we could think of that Borland seem to have missed is the fact that the installation program does not examine the machine's configuration (to detect extended memory, for example). It could then (optionally) configure the IDE to take advantage of your machine's features.

## The Future

What next for Turbo Vision? Turbo C++ users will have read our description of TV with hungry eyes. When will there be a C++ version? Although Borland has certainly not ruled out this possibility, it is emphasising that it has other, higher priorities. The foremost of these is to produce a Windows supporting version of Turbo Pascal. This will become available in the first half of 1991, and will include OOP support for Windows structures. Borland has demon-

```
MenuBar := New(PMenuBar, Init(R, NewMenu(
  NewSubMenu('~T~est', hcNoContext, NewMenu(
    NewItem('~B~GI settings...', '', kbNoKey, 0, hcNoContext,
    NewItem('~G~raph', 'Alt-F5', kbAltF5, cmDoGraphics, hcNoContext,
    NewItem('~S~et BGI path...', '', kbNoKey, cmSetBGIPath, hcNoContext,
    NewLine(
    NewItem('~C~hange dir...', '', kbNoKey, cmChangeDir, hcNoContext,
    NewItem('~E~xit', 'Alt-X', kbAltX, cmQuit, hcNoContext,
    nil)))))),
  NewSubMenu('~W~indows', hcNoContext, NewMenu(
    NewItem('~S~ize/move', 'Ctrl-F5', kbCtrlF5, cmResize, hcNoContext,
    NewItem('~Z~oom', 'F5', kbF5, cmZoom, hcNoContext,
    NewItem('~T~ile', '', kbNoKey, cmTile, hcNoContext,
    NewItem('~C~ascade', '', kbNoKey, cmCascade, hcNoContext,
    NewItem('~N~ext', 'F6', kbF6, cmNext, hcNoContext,
    NewItem('~P~revious', 'Shift-F6', kbShiftF6, cmPrev, hcNoContext,
    NewItem('~C~lose', 'Alt-F3', kbAltF3, cmClose, hcNoContext,
    NewLine(
    NewItem('~Add ~w~indow', 'F4', kbF4, cmNewWin, hcNoContext,
    nil)))))),
  nil)))));
```

Figure 8 - Creating a Turbo Vision menu bar

strated alpha-test versions of this. The hierarchy of Windows classes will not map exactly onto Turbo Vision - Windows, being a full graphical environment, is too complex to allow this - but Turbo Vision applications should be quite easily adapted. Borland also has plans for an OS/2 PM version of the product, and also a DOS extender version, once the DPAPI extended memory standard is firmly established.

## Conclusion

For the devilment of it, we asked Andrew King, Languages Product Manager of Microsoft UK, to comment on Turbo Pascal V6.0. He said, 'The Turbo Pascal V6.0 libraries are satisfactory, but they are only for DOS. Borland has done nothing to address programming for Windows 3.0 in this release.' A fair point, but one gets the impression that he had to scratch around a bit to find something bad to say. Frankly, so did we.

Since this is Turbo Pascal, using it locks you into Borland's proprietary syntax and binary object. As a Pascal user, you have a much narrower choice of third party additions than your C/C++ brethren. Ummf, err...

On the other side of the coin, Turbo Pascal V6.0 is a very good product. Turbo Vision is beautifully designed, extremely powerful, genuinely innovative and fun to use. If you are using an earlier version of Turbo Pascal, then there is no doubt: you should upgrade. If you are thinking about using Pascal, or you need to put together MS-DOS text mode windowed applications, then you should give this product *very* serious consideration.

Turbo Vision is one of those products that is so good that playing around with it has the effect of making you want to use it for real. Will has undertaken a piece of real-life, commercial programming, just in order to satisfy this urge. He promises to report back if it proves any less satisfactory than suggested here. We believe that Turbo Pascal V6.0 is Borland's best effort to date.

EXE

*Paul G Smith left for a trek through the Nepal Himalaya before he could finish this article. Back in the UK he is a software developer, consultant, and writer specialising in graphics, communications and OOP techniques. He can be contacted on AppleLink and CIX as pgsmith.*

*Will Watts remained behind in Chiswick to finish the article and sulk. He cannot be contacted on AppleLink, CIX or even Telecom Gold.*

*Turbo Pascal V6.0 has an RRP of £99.95 plus VAT; Turbo Pascal Professional V6.0 costs £199.95 plus VAT. Various upgrade deals are available, starting at around £50. The product is available now.*

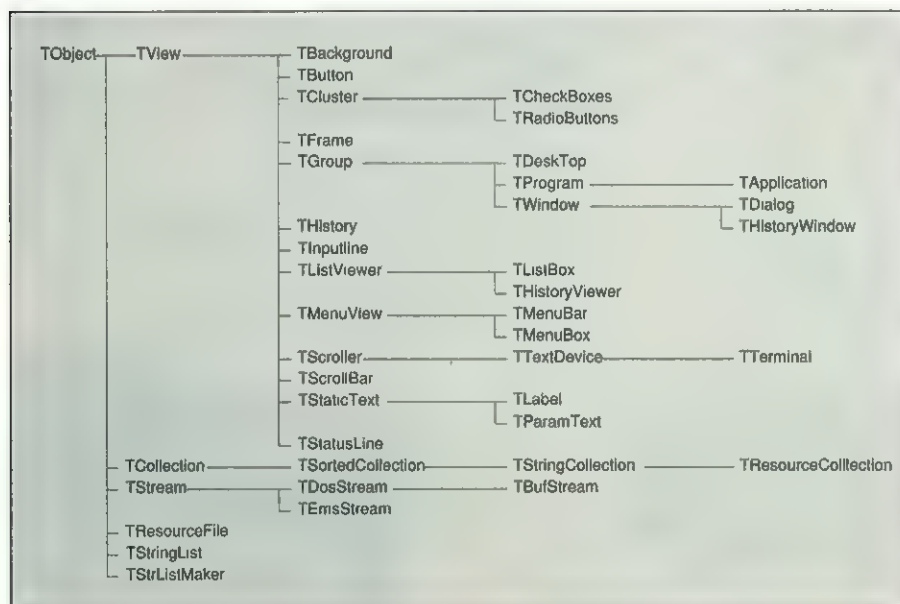


Figure 7 - The Turbo Vision object hierarchy



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# 'I am not Spock...'

*If developers of real time systems thought more about their designs, they might drastically reconsider their choice of processor, says Jon Moseley.*

Increasingly, it's a digital world. The bits are on their triumphal march, with computers and their binary tyranny everywhere. The world of control is no exception; most modern systems are computer controlled by anything from a humble PLC to a huge central mainframe, while virtually all loop controllers (PID types etc) are now micro-processor based.

However, there are problems. When micro-controllers were first introduced they were quickly embraced for implementing digital control systems, and devices like the 8051, the Z80 and the 6301 are now ubiquitous. Wonderful as these chips are (the '51 and I have been 'just good friends' for years now) they aren't really suited to real time control applications.

For a start, conventional micro-controllers are just too damn slow. It is not uncommon for micro-controllers to have a clock rate of just a few MHz. For anything but the very simplest control algorithm (eg a counter or an on/off loop) this will be a major con-

straint - limiting the system to slowly changing environments. An analogue controller built using a couple of op-amps can easily have time constants of under a microsecond - an 8051 will require more than 50  $\mu$ s to implement even the simplest PID loop. This will restrict it to controlling systems with maximum frequencies of about 2 kHz - that's fine for a central heating system, but not really adequate for an engine management system.

As a corollary to this, the response speeds and latencies of these processors are not always adequate for a real time controller, where the ideal is an instant reaction to a problem. That may never be achievable - but it is clearly true that the faster the response the better!

These processors have some arithmetic and architectural deficiencies when used as controllers too. The most popular chips are all 8-bit devices (the 8051 and its cousins alone claim 40% of the total embedded systems market) - and these can suffer from

severe quantisation effects. A resolution of one part in 256 isn't even precise enough to represent 1°, and most applications need more than that. Using a limited dynamic range also introduces truncation and rounding effects - which will manifest themselves as steps or regions of deadband in the response of a control loop. For most real applications, 16 bits internal working is *de rigueur*, even if this will only be used to 8, 10 or 12 bits externally. There can also be problems with overflow - most ALUs warn when there has been an error, but few include hardware (eg saturation registers) to deal with the problem explicitly.

These characteristics have tended to restrict the use of standard, cheap, micro-controllers to the very simplest - slowest - applications. The need for digital control has subsequently led to the development of higher performance processors - the 68000 is very widely used in embedded systems, Intel offers the 8096. But for many applications the same objections apply - these chips are still too slow or too inflexible to cope with the demands of the real time world. So we move on to the current step in the 'Bit race' - the RISC controller.

## The RISC Red Herring

Increasingly, engineers looking to develop fast real time systems are investigating the use of RISC processors. Devices like the Intel 80960 and the AMD 29000 are being expressly marketed on their suitability to life in an embedded application. These products offer the very latest developments in processor design to allow them to run extremely fast. The central theme of these processors is the basic RISC idea - have a basic core of instructions which are hard-wired and run very quickly. However, as well as this, many of these processors employ all manner of clever design tweaks to make them run even faster. For example, the 80960CA (Intel's flagship micro-control-

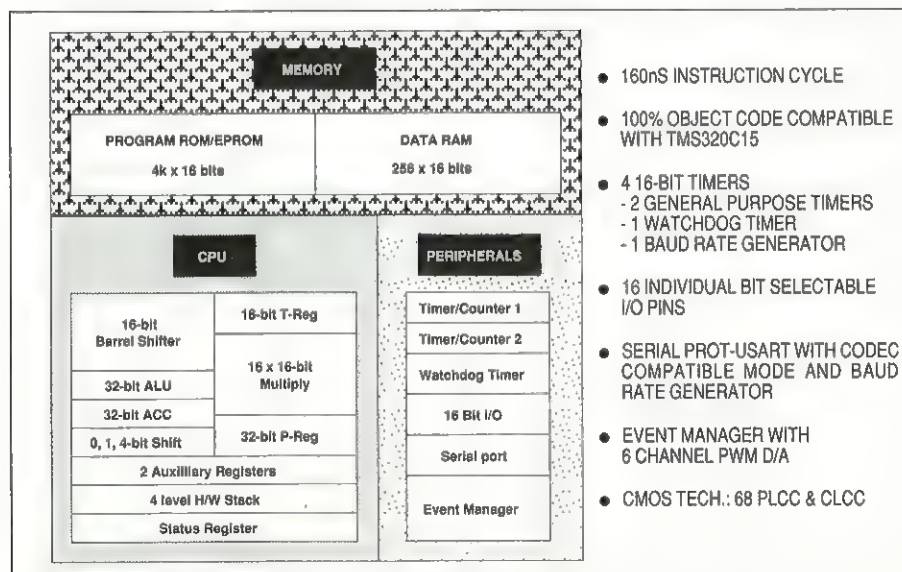


Figure 1 - Key points of the TMS 320C14 DSP based controller

ler) supports three different pipelines, register scoreboarding, resource scoreboarding and a plethora of cache memories for program, data and registers. This is not a simple chip.

However, for all the complexity, speed and power of these processors, they still aren't well suited to the rigours of a real time system. The single, crucial problem is that they are *unpredictable* - the performance of a RISC processor depends on finding data from its cache memory and on instruction smoothly rippling through the pipeline. On average it may execute one instruction per cycle - but it may not. RISC processors are non-deterministic and, at best, only statistically predictable. That is something to beware of in a real time system, where a late response can be more dangerous than no response.

But RISC processors seem wrongly suited to life as a real time controller just from philosophical grounds. The minimalist reduced instruction set philosophy derives from research done by IBM and Stanford University on the efficiency of instruction sets in conventional minicomputers. These processors have been designed for typical programming tasks; word-processors, compilers, operating systems, accounts packages and the like. These tend to be large programs, with a huge number of subroutines and highly complex structures. They operate on vast realms of data with little regularity or structure - any and all of which may be accessed at a moment's notice, suggesting the need for a dedicated pager or memory management unit. And while they have to run 'as fast as possible', there are rarely any demanding constraints on exactly when an instruction has to be completed.

None of this is the case with a real time controller. These have to operate to very tight deadlines and guarantee a response within a strict time window. Rather than large discursive programs, control algorithms tend to be tightly coded and single-minded in their intensity. Nor do they operate on huge swathes of data - instead they concentrate on a narrowly focused set of inputs, operate on them in a tightly structured way and spew out a well organised set of responses, exactly when and where they are required.

This is a long-winded way of suggesting that RISC processors have been designed for the office micro or scientific workstation and aren't necessarily well-suited to steering a robot arm. Using standard RISC processors to force speed into a real time system, rather than thinking about its real needs, seems a short-sightedly machismo

approach ('I've got more MIPS than you'). A real time control system has its own constraints and demands - perhaps it's more rewarding to look for a technique that directly (and efficiently) addresses them.

Similar problems (the need for a fast guaranteed response in a guaranteed time, with

relatively simple algorithms and data structures) were encountered by engineers working in the digital communications industry about 10 years ago. Lacking the luxuries of fast modern processors, but still needing speed, these engineers were forced to develop their own architectures. Thus was born the digital signal processor.

### Who's Who in DSP

Texas Instruments was the first company to produce a popular DSP device (the TMS320C10) and the company has dominated the field ever since. Like its contemporary, the 8088, the C10 set a standard that others have followed, but it is now essentially obsolete and attention focuses on the newer C25 (fast 32-bit integer device) and C30 (very fast 32-bit floating point) processors. Despite the legacy of an ugly instruction set and constipated architecture these devices are ubiquitous; TI has over 60% of the total DSP market.

The company has just launched the C14, a straightforward and rugged device aimed squarely at the micro-controller market. This is a 16-bit device with four timers on-chip (including a watch-dog and a baud-rate generator), six channels of PWM output and a healthy amount of serial and parallel I/O support (see Figure 1). It is intended for mass-market applications and is being evaluated for a number of systems in the automotive industry.

Analog Devices is most famous for the quality of their op-amps and ADCs, but it also has a range of elegant DSP devices in their catalogue. Their AD2100 is a 16-bit integer-only processor, which is starting to look a little dated - rumours abound that new versions are imminent. This is a nimble chip with an elegant architecture and clean instruction set. It's probably most interesting because of its use in an unusual application - Atari selected it as the heart of its *Hard Drivin'* arcade game, which attempts to simulate a racing car. The chip is used as the number-cruncher to process the 3D trigonometry and polygon transforms required in real time.

The giant telecommunications company AT&T developed two processors for its own, in-house, use. The DSP16 is a 16-bit device, the DSP32 is a 32-bit floating point chip. The DSP16 is blindingly fast - with an instruction time of just 25 ns. The DSP32 is no slouch either, with a sustained performance of 25 MFLOPS.

Motorola entered the DSP battle late - giving its designers the chance to take their time and get things right. This it seems to have done. The 56000 is its integer processor. Intriguingly, it's a 24-bit device - the logic for this is that this allows for extended precision internally without the expense of a full 32-bit width (for similar reasons the two ALUs are 56-bits wide). It uses a dual Harvard architecture, with two parallel memory spaces, both of which can be accessed concurrently - say for X and Y coordinates, or the Real and Imaginary components of complex numbers. This device is the *de facto* standard for audio applications; Motorola has got a lovely demonstration using the chip as a stereo 10-channel graphic equaliser. The processor takes the digital output directly from a CD player, processes it and feeds it (via a D to A converter) into a power op-amp. The levels are controlled on the screen of a PC using the mouse. There is a rumour (reported by *Electronics Weekly*) that Motorola is about to launch a 16-bit version of this processor running at a frightening 80 MHz. I don't quite know what you'd do with a processor that fast, but if you're investigating real time adaptive control of a multi-axis robot arm, this is probably the kind of chip you'd want.

The 96002 was only released in July this year, and is easily the most powerful DSP chip available. It is very probably the most powerful microprocessor of any description currently available. With more than a million transistors, it is in the same complexity league as the 68040, the 486 and the i860. Unlike those devices, none of those transistors are wasted on cache memory - all of them are dedicated to number-crunching ability and raw speed. Too powerful (and too expensive) for most control applications, this device is ideal for multimedia controllers, array-processing or serious signal processing.

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EXE - DECEMBER 1991

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CIRCLE NO. 396

## The Solution

At first glance, control systems and signal processors may seem very different. Control systems deal with the real world (servos, motors, sensors etc) while signal processors deal with waves, pulses and information. In fact, the two systems are amazingly similar. Both are true real time systems, and both behave in a similar way: a standard algorithm operating on a stream of data. Given this similarity, it isn't too surprising that digital signal processors turn out to be very well suited to the role of controllers, and can form the basis of very elegant and efficient implementations of a real time systems.

Incidentally, DSP seems to suffer from an appalling image problem. The name isn't impressive - it sounds like some fringe political party and it has an unenviable reputation for being totally incomprehensible. However, DSP is essentially a very familiar occupation - it's merely the idea of treating signals from the real (analogue) world as digital information, and operating on those numbers to get a result. Simple eh? The idea of using a computer to handle 'real-world' tasks, control processes or analyse data seems so commonplace that it hardly deserves to even have a special acronym!

For those of us who like 'arguments from elegance', there's another reason to look favourably at DSP based controllers. While

it seemed philosophically wrong to use RISC processors intended for open workstations in an embedded real time system, there is something aesthetically right about replacing an analogue controller, made with analogue signal processors (amplifiers, filters) with a digital controller made of digital signal processors.

There are a number of different DSP devices available, but the major players in the industry are Texas Instruments, Motorola, Analog Devices and AT&T. They all offer a range of parts intended for different markets and different applications. (The inset box briefly describes some of the more popular ones). However, they all have some features in common:

- They run very, very, very quickly. Even the almost obsolete TMS320C10 has a 25 MHz clock and instruction cycle times of 25 ns are not uncommon. The very latest parts run even faster...
- All of them guarantee one instruction per cycle.
- They are deterministic and wholly predictable.
- They have multiple internal buses and internal DMAs.
- All of them include a fast (single-cycle) hardware multiplier. Most also have at

```

u(n) = u(n-1) + k0 * e(n) + k1 * e(n-1) + k2 * e(n-2)

; GET NEW SAMPLE
PID      IN      E0, PA0
        MPYK 0      ; CLEAR
; ACC = U(N-1)
        LAC  UN
        LT  E2
        MPY K2, E1
; ACC = U(N-1) + K2 * E(N-2)
        LTD  K1
        MPY  E0
; ACC = U(N-1) + K1 * E(N-1)
        ;      + K2 * E(N-2)
        LTD  K0
        MPY
; ACC = U(N-1) + K0 * E(N)
        ;      + K1 * E(N-1) + K2 * E(N-2)
        APAC
        SACH UN, PA1
OUT
  
```

Execution time on standard 25 MHz TMS320C10 = 2.24  $\mu$ s.  
c/f National HPC16083 10  $\mu$ s, Intel 80C196 25  $\mu$ s

Figure 2 - PID Control loop implemented on TMS320C10

least one dedicated multiply accumulator, which means that the operation  $A = B * C + D$  will execute in a single cycle. (The i860 uses a similar architecture.)

- They are designed to apply a single algorithm or operation to a set of data which is in some way regular or structured. For example, in a controller the regularity is that a new input sample is expected every microsecond. In a signal analysis system, the regularity is that there will always be 1024 samples at a time.

### Some current control systems based on DSP devices

- **Disk drives.** DSP devices are used in control loop to move the head over the disk surface as fast and as accurately as possible. They also implement notch filters to keep things stable and eliminate resonances and vibrations.
- **Robotics.** DSP devices are fast enough to cope with the problems of real time control of a multi-axis system - even as it moves. If that doesn't seem difficult, just think how the load and inertia will vary as the arm extends...
- **Active Suspension.** Lotus are using TMS320C14s to measure the pitch and roll of a car and control four hydraulic cylinders to counter these loads - forcing the car to behave in an 'ideal' way.
- **Noise Cancellation.** By listening to a source and generating the 'anti-noise' signal it is possible to reduce the apparent noise of an engine. Lotus are using Texas TMS320C25s to achieve a reduction of about 10 dB in a typical industrial application.
- **Engine Management.** DSP devices monitor engine performance (temperature, pressure, gas content) and vary the control signals (spark timing, fuel/air ratio etc) to get the best possible performance. Since this is an adaptive system (unlike current engine managers) it will cope well with wear, ageing or changing external circumstances.
- **Non-destructive test.** By listening to the way a metal part 'twangs' it is possible to detect whether it is flawed or cracked. A system based on a Motorola 56000 is used by Rolls Royce to test their jet engine turbine blades using this technique.

As an example, consider a PID (proportional - integral - derivative) loop - the commonest control structure. This can be implemented either as a conventional (analogue) system or as a discrete (sampled) signal system. Figure 2 then gives the code for the discrete form, written for the TMS320C10 processor. This was the first really popular DSP device, introduced by Texas Instruments about 10 years ago. Despite its age, it will run this algorithm in approximately 2.24 microseconds - slightly less than an Intel 8096 would take to do a single multiply. Despite its speed, this is emphatically not an expensive, luxury device - a catalogue by my desk lists the one-off price as £10, and I've seen a US ad quoting \$4 in volume.

Of particular interest to readers of .EXE is software development. DSP processors have traditionally had a reputation for being complicated, hard to use and difficult to program. In the past this might have been deserved; the earliest devices (in particular the TMS320C10 series) had very eccentric architectures (that's being kind) which didn't support pointers or loops. As a result,

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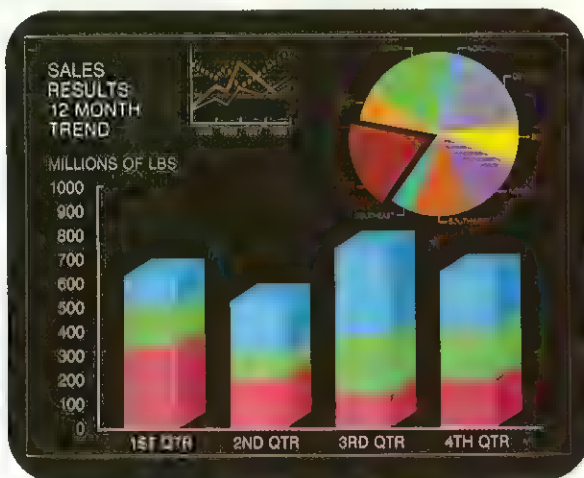
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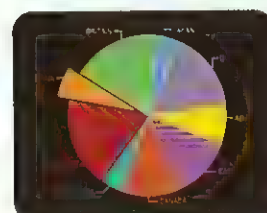
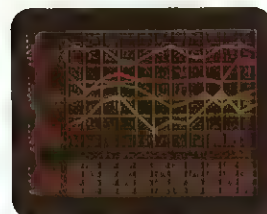
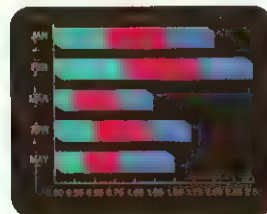
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I N F O R M A T I O N S E R V I C E S

CIRCLE NO. 400

a) P-code (with loops)

```

Start
  For a = 1 to 100
    b = 2 * a
    c = Func (b)
    Out (c)
  Next i
  
```

b) Straight line Code

```

Start
  c =Func (2)
  Out (c)
  c = Func (4)
  Out (c)
  c =Func (6)
  Out (c)
  etc
  
```

Figure 3 - Example of straight line coding

it was much easier to use a macro and copy a piece of code out long hand ('straight line coding') which was confusing to write or debug, and used memory like it was going out of fashion. An example (in pseudo code) is given in Figure 3. In addition, the structure of the assembly language and choice of mnemonics for this processor were beautifully cryptic (see Figure 2).

## Development

That is no longer true. Modern DSP chips all support very powerful pointer structures and addressing modes, and most of them have hardware support for loop operations (ie zero-overhead DO loops). It is no accident that the architecture of the Motorola parts is very reminiscent of their siblings, the 68K series - indeed if you're familiar with 68000 code you'd be able to use the 56000 DSP part almost immediately. The AT&T processors use assembly code that will be instantly recognisable and usable by anyone who knows C (not too surprisingly, since the same firm invented both!). Unfortunately, in the interests of compatibility, Texas has had to retain its weird mnemonics - I suppose that's the disadvantage of being first. If it's any compensation, it is by far the largest company in the DSP market (63% share) and has a huge range of products.

But who cares about the assembly language? Have you ever even seen the assembly language of an 80960 or a SPARC processor? Nowadays, the only people who write assembly code for fast processors are the marketing engineers tweaking benchmarks to get the best possible figures to publish in

the datasheets. Instead, everyone uses compilers for all but the most time critical sections of a program - and DSP devices are no exception. There are some very good compilers and software support systems available for these processors. Often these come from the manufacturers of the silicon, but an increasing number of third party suppliers are involved too. For example, Intermetrics wrote the (excellent) optimising compiler for the Motorola 96000.

In fact (perhaps as a reaction to this reputation?) there are some extremely impressive tools available to help developers use DSP systems. These include software simulators and emulators, graphical development tools and code-generator packages. Packages like Hypersignal or Comdisco's SPW, which let you work from a block diagram of the system and generate code to implement it, have a power and sophistication that rivals some of the best mainstream 4GLs.

Because so much more computational power is available, a DSP-based system gives engineers the opportunities to use better algorithms than would be possible with a conventional processor. As an example consider an adaptive controller.

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A problem with a conventional PID design (whether implemented with an analogue or digital controller) is that its parameters are fixed. If the process changes in any way after initial installation, then the controller will no longer be performing to its best ability and, clearly, the system's closed loop performance is bound to deteriorate. Many processes exhibit behaviour that changes with time; consider the build-up of scale in a heat exchanger, the deterioration in burner condition in a furnace or the variation between different batches of raw materials.

One answer to the above problems is to use a controller that can adapt to changing situations and automatically adjust itself to cope. Essentially, it looks at the behaviour of the system and tries to analyse how it is changing, to ensure that the controller is always running at its optimum performance. This could be done in a heuristic (rule-based) way, perhaps using an expert system, but an alternative is to use mathematical techniques to 'Solve' the system and find the new control parameters (in much the same way that linear regression allows us to find the function relating points on a graph - but varying with time and in N dimensions!). Unfortunately, this requires a stupidly large amount of processing power, which has traditionally limited them to controlling very slow systems. For example, a typical adaptive control system running on a 386/387 combination might have a maximum sampling rate of perhaps 100Hz; limiting it to system frequencies of well below 10Hz. Analogue Devices supply an application note for their AD2100 processor which describes a similar system ('Stochastic Gradient Adaptive Filter') running with a sampling rate of 8 kHz - 80 times faster.

## Conclusion

Like an actor who has performed a famous role and has become type-cast ('I am not Spock - I am a serious actor'), DSP has become pigeonholed as a communications or military technology. This is unfortunate; any system that's primarily doing repetitive numerical work - such as a digital controller - should consider using a DSP device to good effect; either on its own or as a coprocessor. If you're considering a design that requires several processors to do a lot of number crunching, then it's a virtual certainty that a DSP-based solution will be more appropriate, more efficient and probably cheaper too!

EXE

*Jon Moseley was a hardware engineer until he sold his soul and traded soldering iron for a typewriter. Hobbies include sinking jet-skis.*

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CIRCLE NO. 403

# (Not a Speech Disorder)

*If all you know about LISP is that it's slow, it uses LOTS of brackets and it's favoured by the AI community, then it's time you learned more. Your teachers are Al Roth and John Domingue.*

Much has been made recently of Object Oriented Programming (or OOP). C++, we are told, is the shining road to a bright new future. 'Encapsulation, Polymorphism, Inheritance, all these features and more.' But hold on. This isn't new. LISP programmers have been doing this (and much much more) for years. In this article we are going to tell you why LISP is still the language of choice for the cognoscenti. First, some background.

## History

The original LISP programming system was implemented at the Massachusetts Institute of Technology based on a paper by John McCarthy, *Recursive Functions of Symbolic Expressions and their Computation by Machine*, published in Communications of the ACM, April 1960. LISP is certainly **not** new. In fact, the authors know of at least one LISP historian! The first dialect that was used widely was LISP 1.5. The LISP 1.5 Programmer's manual (John McCarthy et al) published in 1962 contained most of the basic concepts found in the majority of existing LISP systems, including lists, functions, mapping functions and recursion. The LISP 1.5 Primer (Clark Weissman), published in 1967, added a macro capability.

Twenty years passed. Various object-oriented extensions were made to LISP, developed by various different vendors. It was time to standardise. The ANSI X3J13 committee was formed, with the job of defining a Common LISP standard. X3J13 adopted the first two chapters of the Common LISP Object System (CLOS), with the result that Common LISP now supports a powerful object-oriented programming system.

## Rudiments

The first thing to do is have a crack at the ubiquitous triangle problem (given to us poor writers as homework by .EXE's Editor). In fact, we have devised two LISP solutions to it, shown in Figures 1 and 2.

Figure 1 shows a basic solution, such as might be attempted in an ALGOL derivative. Figure 2 is a more LISP-y effort, being based on higher-order constructs. The solution is far more general and there is no hard coding. The program is generic - it could handle shapes like squares and other polygons - not just triangles. This flexibility is a hallmark of LISP.

So that's the homework done, gold stars all round please. But what does the code show? There are some features of LISP that make it both unusual and extremely powerful. The first is that functions are first class objects - they can be used in the same way as other normal data objects, for example, assigned to variables and passed to functions. One of the common ways this is used

```

;;; Triangle Problem for .EXE in LISP
;;;
;;; This mirrors a conventional language, and avoids using
;;; any of the more esoteric and powerful functions.
;;;
;;; First define a constant for the number of sides in a triangle.

(defconstant sides-per-triangle 3)

;;; The main entry point. Call the function from top level by typing:
;;; "(triangle)".
;;;
;;; (dotimes (index total) (print index))
;;; will print out the numbers from zero up to (not including) total. dotimes
;;; is the simplest and most primitive iteration construct in Common LISP.

(defun triangle ()
  (let ((sides (read-triangle sides)))
    (format t "~>Triangle entered~%")
    (dotimes (side sides-per-triangle)
      (format t " ~>" (aref sides side)))
    (cond ((not (trianglep sides))
           (format t "~%This is not a triangle~%"))
          ((equilateralp sides)
           (format t "~%This is an equilateral triangle~%"))
          ((isoscelesp sides)
           (format t "~%This is an isosceles triangle~%"))
          (t
           (format t "~%Triangle is scalene~%")))))

;;; Read three values and make them into an array. Common LISP guarantees
;;; left-to-right evaluation.

(defun read-triangle-sides ()
  (vector (read) (read) (read)))

;;; Definition of test for valid triangles.

(defun trianglep (sides)
  (not (or (> (aref sides 0) (+ (aref sides 1) (aref sides 2)))
          (> (aref sides 1) (+ (aref sides 0) (aref sides 2)))
          (> (aref sides 2) (+ (aref sides 0) (aref sides 1))))))

;;; Definition of test for equilateral triangles. Note that using prefix
;;; notation for operators means they can take more than two operands, as in
;;; this case with "=".

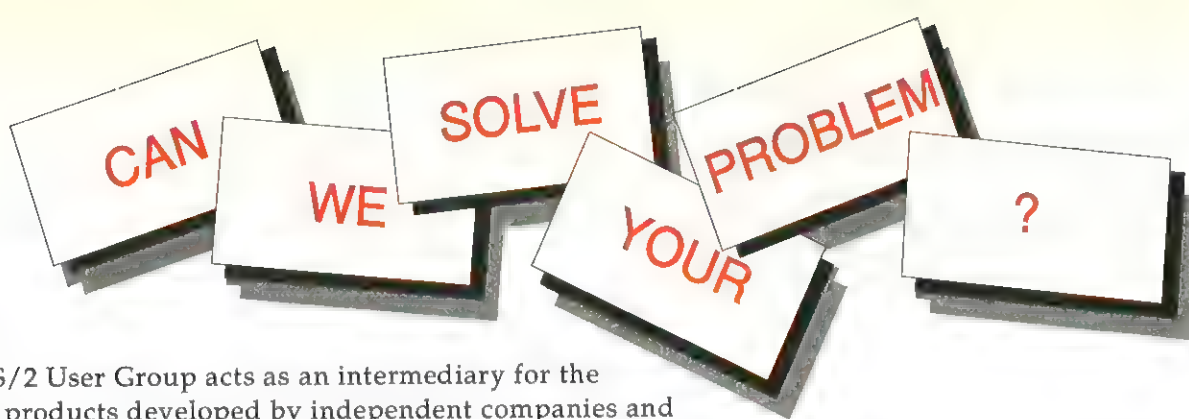
(defun equilateralp (sides)
  (= (aref sides 0) (aref sides 1) (aref sides 2)))

;;; Definition of test for isosceles triangles.

(defun isoscelesp (sides)
  (or (= (aref sides 0) (aref sides 1))
      (= (aref sides 0) (aref sides 2))
      (= (aref sides 1) (aref sides 2))))

```

Figure 1 - The Triangle Problem, conventional approach



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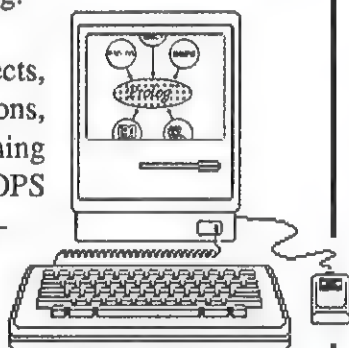
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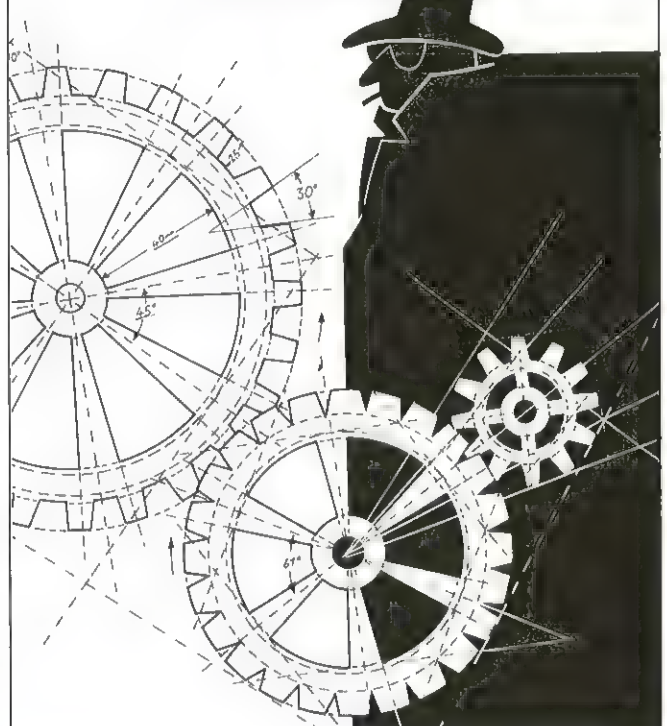


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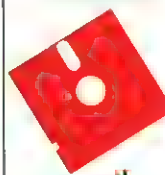
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CIRCLE NO. 405

```

;;; Triangle Problem LISP style
;;;
;;; Note only one function in this version actually knows about
;;; triangles. Demo with (polygon 'triangle)

;;; To extend write a new function say quadrilateral
;;; and insert the name into the assoc list below,
;;; (quadrilateral . 4)
;;; a function should take one argument a list of the sides
;;; in the polygon and return t if the sides
;;; satisfy the appropriate constraints and nil
;;; otherwise.

(defvar *polygon-number-of-sides*
  '(triangle . 3))
;; to be added (quadrilateral . 4) (pentagon . 5))

(defun polygon (polygon-name)
  (if (know-polygon-name? polygon-name)
      (process-polygon polygon-name)
      (apologize polygon-name)))

(defun process-polygon (polygon-name)
  (let ((sides (read-sides (number-of-sides polygon-name) polygon-name)))
    (when (passes-polygon-test polygon-name sides)
      (polygon-checks sides polygon-name))))

(defun know-polygon-name? (polygon-name)
  (number-of-sides polygon-name))

(defun number-of-sides (polygon-name)
  (cdr (assoc polygon-name *polygon-number-of-sides*)))

(defun apologize (polygon-name)
  (format t "~%Sorry, I do not know of the polygon ~a" polygon-name))

(defun passes-polygon-test (polygon-name sides)
  (let ((test-result (funcall polygon-name sides)))
    (format t "~%This is~{ not~;~} a ~a" test-result polygon-name)
    test-result))

;; I've assumed that the checks below are for all polygons
;; if you disagree then put them back into triangle
(defun polygon-checks (sides name)
  (format t "~%This is a ~a ~a~%" (polygon-type sides) name))

(defun polygon-type (sides)
  (or (equilateral-type sides)
      (isosceles-type sides)
      'scalene))

(defun read-sides (number-of-sides name)
  (let ((sides nil))
    (format t "~%Enter the ~a sides of the ~a: " number-of-sides
            name)
    (dotimes (i number-of-sides)
      (push (read) sides))
    (format t "~%~a sides entered:~{ ~D~}." number-of-sides (reverse sides))
    sides))

;;; Both equilateral and isosceles tests use remove-duplicates, which
;;; coalesces duplicate elements in a vector. If all elements are the same,
;;; the length of the result will be one. If two are the same, it will be one
;;; less than the length of the original vector.

(defun equilateral-type (sides)
  (when (equilateralp sides)
    'equilateral))

(defun isosceles-type (sides)
  (when (isoscelesp sides)
    'isosceles))

(defun equilateralp (sides)
  (= 1 (length (remove-duplicates sides))))

(defun isoscelesp (sides)
  (= (1- (length sides))
     (length (remove-duplicates sides))))

;;; The triangle functions. This is the ONLY function that knows
;;; about triangles.
;;; Definition of test for valid triangles. First get the total length, and
;;; check if any side is greater than half of it. reduce combines all the
;;; elements in a vector, using a function. "(reduce #' + sides)" returns the
;;; sum of all elements in "sides".

(defun triangle (sides)
  (let ((half-length (/ (reduce #' + sides) 2)))
    (notany #' (lambda (side)
                  (> side half-length))
             sides)))

```

Figure 2 - The Triangle Problem, LISP style

is to replace iteration. It's easy to see why. This piece of code declares a function, `increment-list`, which accepts a list parameter and returns the list with each element incremented:

```

(defun increment-list (list)
  (let ((new-list nil))
    (dotimes (i (length list))
      (push (1+
              (elt list i))
            new-list))
    (reverse new-list)))

```

This piece of code does the same job:

```

(defun increment-list (list)
  (mapcar '1+ list))

```

`mapcar` is one of the set of mapping functions. It applies a function (in this case `1+` increment) to each element in a given list. Mapping functions such as `mapcar` rely on the fact that a function can be passed as an argument in the same way as normal data. This allows the programmer to write code at a more abstract level, a technique which underlies the second version of the Triangle Problem solution.

This point about being able to write code at a more abstract or generic level is an important one - LISP allows you to develop very generic solutions. Prof Gerry Sussman (MIT AI Lab) once said, 'If you are given a problem to solve, write a solution that solves the CLASS of problems you have been given, then write your solution as one of the class'.

## OOP in LISP

Let's look at some features of LISP as a language for object oriented programming. Inheritance allows a newly created class to use some or all of the attributes of an existing class. This speeds development (because existing classes can be used to build more complex ones) and economies of storage (characteristics can be stored at the highest place to which they hold true). LISP also offers multiple inheritance, where a class inherits its attributes from more than one parent class. This is a very powerful feature. Certain object hierarchies, if implemented without multiple inheritance, force you to replicate some of the code.

A *generic function* is a function whose behaviour depends on its arguments. In most object oriented languages, the behaviour depends on the first argument. For example, `(move king7)` would exhibit different behaviour from `(move rook3)` if `king7` and `rook3` were instances of classes `king` and `rook` respectively. Flavors and Smalltalk use a message and 'send'. In Flavors notation, `(move king7)` would be expressed as `(send king7 move)`. Generic functions are made up from a collection of methods, each acting on a different class. Each method

specifies the behaviour of a generic function for a particular class. In our example there would be two methods: one for class king and one for rook.

Methods that are selected on more than one class (or argument) are called *multimethods*. These are useful when the behaviour of a function is determined by more than one thing. If you were writing a generic function to determine what happened if objects crashed into each other, the result would depend on both objects. A juggernaut - bicycle collision would have a different outcome than a juggernaut - juggernaut collision.

Multimethods provide a neat way to achieve this. They also help you to write programs in the true spirit of OOP: objects do not really have to 'know' about each other. For example, if we add a car as a candidate for catastrophe, we should not have to make changes to either juggernaut or bicycle.

When a message is sent to an object, or a generic function is called, the system must determine exactly which method should be executed. A number of methods may be in contention. *Method combination* is the term used to describe how the competing methods are applied. The simplest example of a type of method combination is that of just using the most specific one. CLOS has three standard other method combinations.

- before - the method is used before existing methods,
- after - the method is used after existing methods, and
- around - the method is used before and after existing methods.

These method combination types allow programmers to add new code with little knowledge of existing code. Suppose a class robot exists with the generic function ask. Ask is called every time the robot wants something. A programmer could create a new class polite-robot, by augmenting the generic function ask:

```
(declass polite-robot (robot) ())

(defmethod ask :before
  ((x polite-robot))
  (print "excuse me"))

(defmethod ask :after
  ((x polite-robot))
  (print "thank you"))
```

A polite robot would always say 'excuse me' before any request and 'thank you' afterwards. Notice that we have created this new behaviour without any knowledge of how robots were implemented.

## Data EQ Program

LISP code and data are both made of the same type: lists. (The name LISP came from **LISt Processing**). Program and data equivalence is perhaps the most important feature of LISP, because it helps the construction of programs that create and manipulate other programs. LISP programmers often write programs that can create new functions at run-time. Program data equivalence also allows the programmer to write programs that change themselves, but this is not as frequent. Although it is possible to write Pascal or C programs that manipulate themselves, it is much harder.

Gregor Kiczales, one of the designers of the CLOS, related a useful anecdote at last year's European Conference on the Practical Applications of LISP. The implementation of a window management program (a program which controls the display of a system where multiple windows are present) was greatly simplified, both conceptually and in terms of code quality, when the central data structure which held all the windows (as a stack) was regarded as a program. Kiczales also claimed (and so do we) that this sort of switch between program and data was much more likely to occur when LISP is being used as the implementation language.

It has been noted by Prof Erik Sandewall that LISP is also ideal for implementing special purpose programming languages (SPPL). An SPPL is designed to address a limited application domain, or a specialised function in software. Spreadsheets and database query languages are examples of SPPL that are very popular in the conventional software world. In the field of AI, Sandewall believes that they have been a standard methodology and have embraced ATN parser systems, frame databases, rule-based systems and reason maintenance systems.

## LISP v the rest

One clear LISP advantage relates to compiler technology. Incremental compilation is not a feature of most languages. Make a change to a C routine, and you have to recompile the lot. Change a LISP function, you merely evaluate the changed code.

A second general point is that LISP uses dynamic binding. This allows the characteristics of an object to change according to conditions created by the program. Static binding (as in C++) is less flexible, but produces more efficient code.

This trade-off is one that requires careful thought during software development. It has led people to suggest that the price for using LISP is a loss in performance. We do not believe this to be true. In the early days LISP programs were interpreted and so performance was poor. The interpreters were usually written in assembler or conventional high-level languages. More recently, however, LISP compilers have been developed which are themselves written in LISP, an application of the compiler technology of imperative languages such as Pascal. Since the programs themselves are written in LISP data structures, optimisation is easy - easier than with many conventional languages. The final code can be very efficient indeed. The S-1 LISP implementation has achieved comparable performance to FORTRAN running on a Cray.

Since 1985, there has been a standard set of benchmarks for measuring the performance of different LISP implementations. This led to a healthy competition between vendors, although admittedly at the expense of some special optimisation towards the benchmark programs. Today's Common LISP programs are very fast indeed.

## Conclusion

LISP has been around for a long time. With the continuing development of such projects as the Common LISP Interface Manager (a generic front-end which will be portable between platforms) and various parallel LISPs (more on these another time, perhaps), LISP surely also has a bright future. LISP offers a mature and robust object oriented programming system which includes features simply not provided anywhere else.

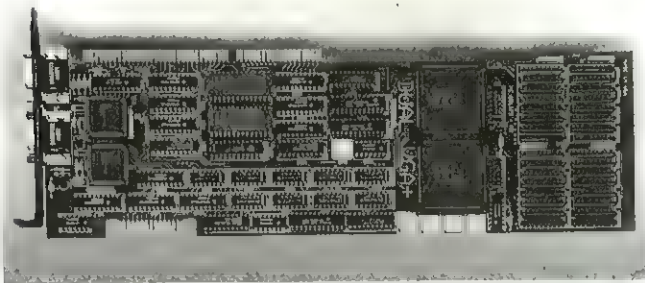
EXE

*Al Roth is an AI consultant and media specialist. Dr John Domingue is a research fellow at The Human Cognition Research Laboratory at the Open University. Together, with David Lloyd and Dr Tim Rajan, they co-founded EUROPAL - The European Conference on the Practical Applications of LISP.*

*The authors would like to thank Stuart Watt of Scientia Ltd for his contributions to this article.*

*EUROPAL '91 will be held March 24th - 27th at Churchill College, Cambridge. Anyone interested in this conference should contact David Lloyd at EUROPAL, PO Box 110, Dorking, Surrey, RH5 4FB, or phone 0306 889 485.*

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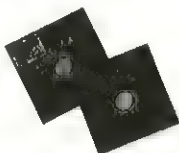
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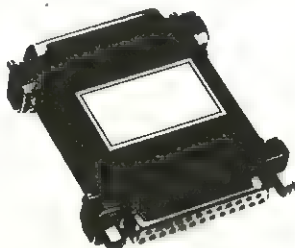
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# Windows Stubs

*'This program requires Microsoft Windows', and you're thrown back at the MS-DOS prompt. Where is the code that prints this abrupt refusal? Jeff Goldberg explains.*

Offset	Contents
0-1	"MZ" for DOS executable
2-1Bh	DOS header
1Ch-3Bh	DOS relocation table
3Ch-3Dh	"NE" for New Executable. Start of Windows header
3EH->>	Rest of Windows header, data tables and code.

Figure 1 - Simplified Windows .EXE Header

Have you ever wondered how Microsoft's Excel or Windows Word started up Windows when run from the DOS prompt? This article will tell you how and provides some sample code.

First take a look at the (simplified) structure of a Windows .EXE header (Figure 1). You'll notice that it starts with the same header as a normal MS-DOS program, albeit with a restricted relocation table. This allows the Windows .EXE file to cheat the MS-DOS loader into thinking it's an MS-DOS .EXE file. A Windows loader would ignore the 'MZ' at the front of the file and search for 'NE' at offset 3Ch into the file. (Incidentally, the 'MZ' comes from the famous Microsoft programmer Mark Zbikowski, who wrote large parts of MS-DOS.)

The upshot of all of this is that the program run at the DOS prompt is a very ordinary, plain vanilla .EXE program. This program is known as the *stub* in Windows terminology, and is defined in the linker definition (.DEF) file. For example, to use the stand-

ard stub you create a definition file something like the one shown in Figure 2. The important line is the STUB 'WINSTUB.EXE', which means that WINSTUB.EXE is the program bound into ASCII.EXE to be run in the DOS (rather than the Windows) environment. You cannot, unfortunately, use a .COM file as a stub - the linker doesn't allow it.

## The executing stub lets your program behave like Excel or Windows Word

Our first replacement stub (Figure 3) is pretty well the smallest stub possible. All it does is put out the familiar *This program requires Microsoft Windows* message and terminates. To use it, you should compile and link it, then change the STUB command in the appropriate .DEF file. At 568 bytes (using TASM and TLINK) it is 42 bytes smaller than the standard Windows 3 offering.

Some programmers, however, want to generate large programs, to prove that they

have done a lot of work. There is no better way of increasing the size of the .EXE file than making a big stub. For example, the executing stub shown in Figure 4 makes a 6 KB file when compiled.

The executing stub lets your program behave like Excel or Windows Word, starting up Windows if run from DOS. It is very simple, merely retrieving the arguments from the command line and using the library function `system()` to call DOS. `system()` uses the path and the current directory to find WIN - if some problem occurs it returns with 1 and sets `errno`. The stub will only execute Windows under MS-DOS V3.0 or above, since earlier versions did not give the program name as an argument to the program. I used Borland's Turbo C++ to compile and link the stub, but it should port to other compilers unaltered.

NAME	ASCII
DESCRIPTION	'Ascii Table'
STUB	'WINSTUB.EXE'
CODE	MOVEABLE
DATA	MOVEABLE MULTIPLE
HEAPSIZE	1024
STACKSIZE	4096
EXPORTS	WndProc AboutDlgProc

Figure 2 - Example .DEF file

```

DOSSEG
.MODEL SMALL
.STACK 100h
.CODE

Start:
    push cs
    pop  ds
    mov  ah, 09h
    lea  dx, DosProgramStr
    int  21h

    mov  ax, 4c01h
    int  21h

DosProgramStr:
    db  'This program requires '
    db  'Microsoft Windows'
    db  13,10,'$'

END Start

```

Figure 3 - The TINYSTUB program

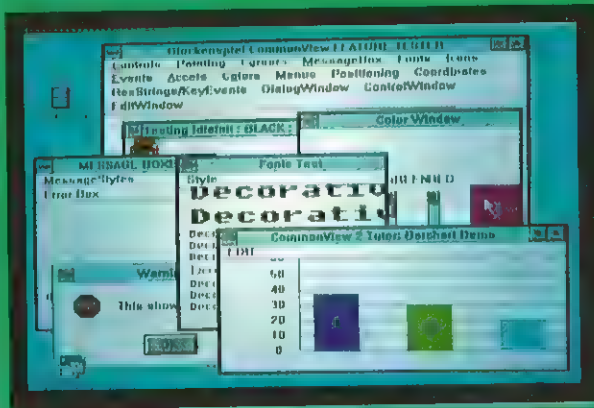
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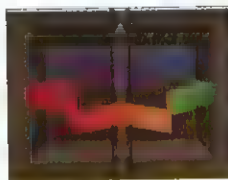
Glockenspiel CommonView 2 includes Glockenspiel C++ 2.0 and Container - the object storage framework. It requires Microsoft C 6.0, the Windows SDK and 1.5 meg of memory. You debug C++ source with Microsoft CodeView 3.0. Glockenspiel C++ supports a completely portable memory management system. Glockenspiel CommonView consists of approximately 65 classes

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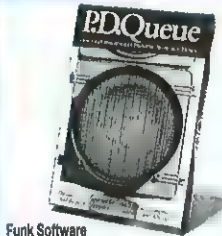
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```

/* Demonstration of a stub that starts up Windows
   if at the DOS prompt

Version 1.0 by Jeffrey Goldberg Oct 90

*/

#include <string.h>
#include <stdlib.h>
#include <errno.h>
#include <stdio.h>

main (int argc, char *argv[])

{
    char CommandBuffer[300]; /* Big enough to satisfy */
    char MSWinName[]="WIN"; /* Current name of Windows */
    int i;

    strcpy(CommandBuffer, MSWinName); /* Copy Win into buffer */
    for (i=0; i<argc; ++i) { /* Copy command line params */
        strcat(CommandBuffer, " ");
        strcat(CommandBuffer, argv[i]);
    }

    if (system(CommandBuffer) == -1) { /* Problem */
        fputs("Error executing Windows because ", stdout);
        switch (errno) {
            case E2BIG:
                fputs("your argument list is too long.", stdout);
                break;
            case EACCES:
                fputs("MS-DOS denied you access to Windows.", stdout);
                break;
            case EMFILE:
                fputs("MS-DOS has too many open files.", stdout);
                break;
            case ENOENT:
                fputs("Windows is not in the current path.", stdout);
                break;
            case ENOEXEC:
                fputs("of an invalid COMMAND.COM.", stdout);
                break;
            case ENOMEM:
                fputs("of a lack of memory.", stdout);
                break;
        }
        fputs("\n", stdout);
        return 1;
    }
    return 0;
}

```

Figure 4 - A Stub which starts up Windows

These are just two simple (but useful) examples of stubs. If you wish to take this idea to its logical extreme, you should create a stub that contained code equivalent to the Windows program, running under a

character version of Windows. Then you would have, at the cost of considerable effort, the equivalent of those dual-mode applications that run under MS-DOS and OS/2...

Jeffrey Goldberg ('cricket' on CIX) has worked on the Psion MC600, Borland's SideKick Plus and SideKick for PM. He is currently looking for his next project...

EXE

## Accelerate Windows 3.0 Development with WinTrap

### What is WinTrap?

WinTrap is a software module that monitors all calls to Windows functions and immediately reports which function has failed if an error occurs.

### Who should use WinTrap?

Anyone developing a Windows 3.0 application will benefit from using WinTrap. This includes anyone who cannot readily run CodeView (PS/2 and portable users, and any PC without sufficient RAM). WinTrap can also be used to supplement/replace CodeView to localize errors immediately thus avoiding time consuming rebuilding and tracing.

### Why use WinTrap?

The "UNRECOVERABLE APPLICATION ERROR" syndrome costs the average Windows developer about three weeks productivity a year. Scale this by the number of developers on a project and you have the answer. If WinTrap reduces production time by one day, it will have paid for itself.

### How easy is it to use WinTrap?

Very. Simply add one line to two of your application build files and you are ready to use WinTrap.

### Where can you get hold of WinTrap?

WinTrap costs £99 and is available from: WinSoft Systems, Martinstown, Kilmallock, Co. Limerick, Ireland. Telephone: (010 353 63) 88108

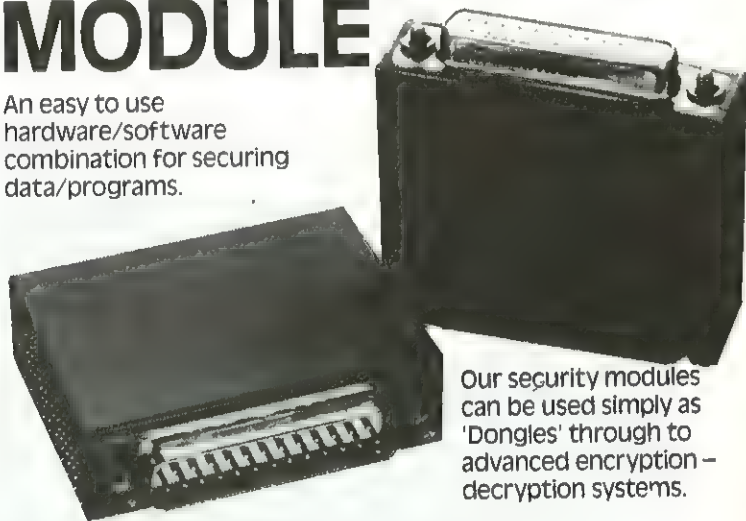
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# Dawn Chorus

*As UNIX matures, so its kernel becomes obese and overweight.  
Peter Collinson explains one approach to keeping it small and sprightly.*

The sound of letters dropping through the box makes me wander bleary-eyed downstairs. Press releases. Who writes these things? And who do they think they are writing them *for*? Wait a minute, this is interesting... Unisys, a huge American company will be basing its UNIX development on the tiny kernel of a small French company, Chorus systèmes. There is perhaps one technical word of interest in three pages of verbiage, and that word is 'microkernel'. What is microkernel architecture? Why is it interesting?

## Kernels

Let's start by looking at the context. The UNIX kernel is the machine resident part of the operating system. It is loaded into the machine at bootstrap time and remains there unchanging until the system is re-booted. Its job is threefold. First, it deals with all those nasty peripherals and forces them to present a consistent interface to the programmer's running program, known as a *process*. Since UNIX is a multi-user time-sharing system, the kernel will manage re-

sources ensuring that all processes get a fair share of the machine. Finally, the kernel will provide various hidden services to allow processes to stretch the physical resources of the machine: the kernel will manage virtual memory or swapping.

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***One day  
all operating  
systems will be  
built this way***

---

The kernel allows the programmer to see a consistent view of the world by presenting a model of a virtual machine. Above the kernel is a set of processes running using the virtual machine model. The processes are independent and are unaware of each other. They communicate with the outside

world only using system calls into the kernel.

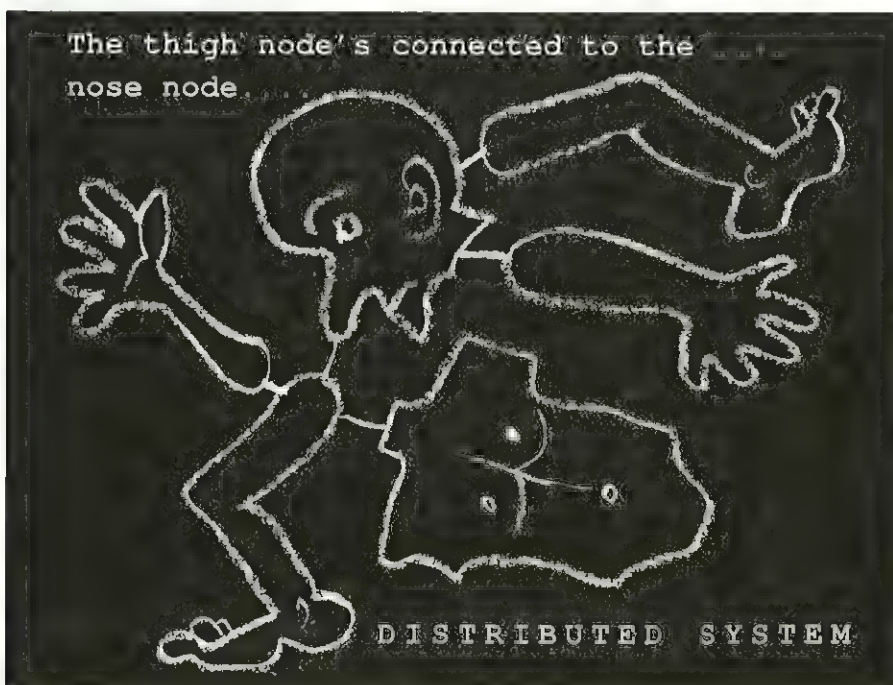
The early kernels were small, constrained by the address space of the PDP-11. Kernels have grown. The kernel size doubled when the folks at Berkeley added the socket mechanism to support TCP/IP in 4.2BSD. The newest release from AT&T, System V release 4, is intended to join all the features of the existing System V releases with many of the features from the BSD world. The idea is to provide a coherent UNIX platform supporting user code from both environments. The result will be a large resident kernel that we will all have to grow to love. In reality, we will complain and grudgingly accept the inevitable because we all need to migrate to a single UNIX software platform.

The large resident kernel has become a 'problem' of UNIX. It will be quite possible for your application to run happily in a UNIX subset where sections of the kernel code will not be touched. In reality, you would prefer to use that memory for your programs.

Well, you say, just don't compile that bit in. That's OK, until I visit your site bringing my favourite program that just happens to use the part of the kernel that you don't have. Worse, you could have bought a system from a helpful vendor who is convinced that some obscure part will never be needed; and all is hunky-dory until you buy the shrink-wrapped box that just happens to need the omitted part. The product just won't run on your so-called *standard* UNIX machine.

So why not have loadable drivers? This is certainly possible, but some things cannot easily be split from the kernel as it stands now - so loadable drivers may not prove to be much of a win.

We have a problem that seems difficult to solve with the existing versions of UNIX. How can Chorus help?



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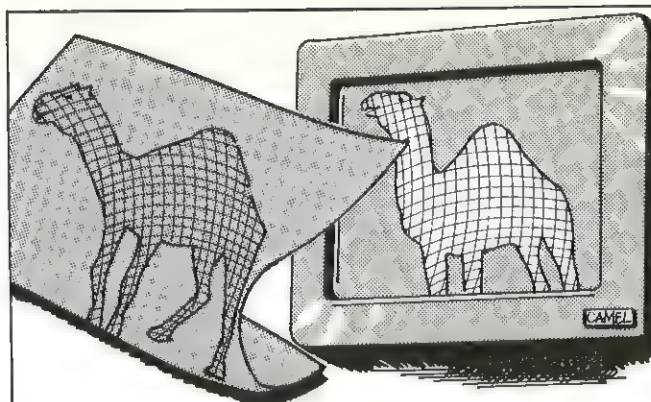
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## Distributed systems

Chorus springs from work on distributed operating systems and has only become a UNIX platform in recent times. A distributed operating system appears to the user as a single coherent machine, even though resources are spread over several machines. This differs from the more familiar model, a networked operating system, where the user is aware that other machines exist and is able to easily access resources on any of them.

Distributed systems have a big problem: identifying and using resources. When a process wants to read a file, it will eventually call the `read` routine. In a non-distributed system, this becomes a system call which can be thought of as a subroutine call into the kernel. Kernel code is executed and a result copied into the memory of the process. Finally, the `read` call will return, passing some success or failure code to the caller.

In a distributed system, this same `read` call cannot necessarily be executed on the machine where the original process is running. The call is coded as a *message* and this is sent to the code that deals with file system management, wherever that may be located. The file system manager cannot directly copy the read data back into the memory of the client process, since both processes may be on different machines. It will reply using a message and this will be sent back to the client. Typically, the `read` routine will be waiting for the message and will return success/failure to the caller as before.

Distributed systems provide message passing as a primitive operation. They code all forms of communication between programs as messages. Considerable work has been done over the years to make message passing operate efficiently. The big problem is the amount of copying of the data that is needed. Chorus makes for a great efficiency win within one machine by using page flipping in the virtual memory to move messages. Simply, pointers to messages are used to move the data between separate processes, avoiding any data copy operations.

Message passing is a key breakthrough in kernel writing. The kernel can be split into several distinct tasks whose job is to listen for a message, take some action and return the answer in a message. Many of the transactions that were traditionally handled inside the kernel can be moved into separate servers located anywhere on the network. These servers become easy to write and understand since they fulfil the criteria for

all good UNIX programs: a program doing one thing well.

## Chorus

A Chorus distributed system will consist of a set of computers. Chorus calls these *sites*. A site is a closely coupled set of resources: one or more processors, memory and I/O devices. Sites are connected by a communications network, maybe a LAN or perhaps a bus.

If you look inside a site, you will see a tiny resident kernel or the 'microkernel'. This is called the *nucleus* in Chorus. It has two well-defined functions.

## Distributed systems have a big problem: identifying and using resources

First, it manages local services on the site. It provides a portable real-time multi-tasking executive used to schedule and synchronise what is happening on the machine. It contains a virtual memory manager used to control local memory resources. This is mostly portable, although it does require some machine dependent hooks. It contains a machine dependent *supervisor* used to dispatch external events - interrupts, traps or exceptions.

Second, the nucleus supports a message passing system that is a global service accessible by the whole distributed system. Again, this is portable. The inter-process communication (IPC) manager is responsible for delivering messages whatever their destination within the distributed system. The IPC manager can rely on network management servers that are external to the kernel and are used to operate various protocols over the current network.

## Actors

There is a set of processes running on top of the nucleus; these processes are called *actors*. An actor supports the execution of one or more *threads*. You should think of a thread as an execution path through the code. However, there can be more than one thread running in parallel through the

actor. This implies that there is support for lightweight processes that will share the same address space in each actor.

An actor defines an address space that is split into a user part and system part. The system address space is shared between all the actors on the site and can only be accessed when the actor is allowed to use privileged levels of execution. Actors don't migrate. They are restricted to a particular site and their threads are executed on that site.

IPC messages flow between actors addressed to *ports*. Threads read and send messages to ports. This allows migration of services since the port (and any queued messages it is holding) can move from actor to actor. Ports have an address that is unique over the whole distributed system, this is supported by the notion of the Unique Identifier (UI). The nucleus supports a name look-up system mapping UIs onto real ports, so again we have transparency - threads can use these names without any knowledge of their actual location. It is possible to transfer UIs between actors so the knowledge of a particular service can easily be moved around the system.

## Mapping UNIX onto Chorus

UNIX facilities can be split into several distinct services depending on the type of resource being managed. Chorus builds a UNIX system from a set of system servers each running in a single actor. Individual UNIX user processes are themselves actors. Notice that Chorus expects all actors to communicate amongst themselves to achieve a particular task. You should contrast this with the UNIX model where everything talks to the kernel.

Chorus supplies five system servers making up the UNIX subsystem. The *Process Manager* executes services directly related to UNIX process management: `fork` and `exec`, signals and the like. It supplies shared system code supporting a control mechanism for signal handling and providing the UNIX system call interface. When the process manager cannot execute a UNIX system call itself, it calls other servers to do the job.

The *File Manager* supplies file management services. It maintains all the bag and baggage associated with a traditional UNIX file system. A Chorus system consisting of several sites can have several file managers. Chorus provides a way to link the file system trees together to form a complete single file tree spread over the network.

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*Device Managers* operate asynchronous lines, bitmapped displays, pseudo-ttys and the like. They also support UNIX line disciplines. Several device managers can run simultaneously on a site servicing different peripheral devices.

The *Pipe Manager* supports UNIX pipes, providing management and synchronisation. Requests for named pipes (FIFOs) are received by the file manager and forwarded to the pipe manager. Pipe managers may be active on every site, reducing network traffic when pipes are invoked from disk-less workstations. Finally, the *Socket Manager* provides 4.3BSD socket services giving access to TCP/IP protocols.

System servers run in either user or system space. Those needing to connect some of their routines to UNIX system calls will run in system space, as will those needing to execute privileged instructions, like I/O operations.

## A configurable UNIX

Chorus, then, provides a modular design allowing static and dynamic configuration

of distributed systems. Once you have created a structure where servers provide resources to other processes, it is possible to take advantage of the modularity of the system in several ways. You can drop unneeded servers to generate special purpose systems, or you can replicate servers to provide fault tolerance. On a stand-alone machine, you don't need the network protocols so you can lose the network manager. On a diskless workstation, you don't need a file manager. The process manager converts UNIX file system calls into IPC requests, allowing transparent access to the file managers running on other sites.

Chorus provides easy support for multi-computers. When Chorus runs on a multi-computer like a hypercube, it can treat the hardware in a similar way to a network of servers and workstations. It is possible to make each node look like a full UNIX system to application programs, while placing the various servers at strategic points in the architecture. File servers, device managers and the socket manager will be loaded on the nodes where the appropriate peripherals are attached.

Chorus is a glimpse of the future. Maybe, over the next decade, all operating systems will be structured this way. Chorus is interesting because it is written in C++, is well developed, and has been evolving for 10 years. It is well-engineered in the sense that ingenious solutions have been found to many of the problems associated with message passing, handling interrupts efficiently and minimising context switches. Look out for it.

EXE

*Peter Collinson is a freelance consultant specialising in UNIX. He can be reached at pc@hillside.co.uk electronically (although your mailer might be happier to put the address the other way round) or by phone on 0227 761824.*

*More reading - there are no books on Chorus as yet. The best reference material is a technical paper published in Computing Systems, the Journal of the USENIX Association, Volume 1, No. 4, 1988.*

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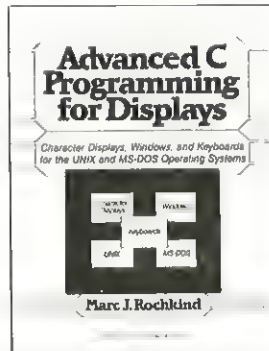
## A Fine Character

*Advanced C Programming for Displays* is perhaps a slightly misleading title, as it suggests (to me) elaborate graphics: fractals, better line-drawing algorithms, rendering etc. This book covers only character-based displays; specifically managing the MS-DOS/PC display and driving UNIX terminals. You wouldn't think there was very much meat here. After all, once you know how to clear the screen and position the cursor, there is nothing much more to a text display, is there?

The book is based around the development of a sort of 'virtual console' library. The first chapter contains a general overview of user I/O, dealing with such concepts as character-based versus graphics displays, windows and [Microsoft] Windows and so on. The author explains why, despite the success of the Apple Macintosh and other GUIs, character-based programs are still important.

Chapter 2 defines a minimal character set and introduces a few generic constants for box-line drawing. A structure to hold the coordinates of a rectangle is introduced, plus a few macros to manipulate it (these are used as the basis for operations on windows throughout the book). A number of routines are supplied to overcome tiresome system/compiler dependencies. As the book is a few years old (published 1987), and the author is trying to be portable between UNIX and MS-DOS, the code is all written K&R style. The environments explicitly supported (by `#define` constants) are Lattice C/MS-DOS, Microsoft C/MS-DOS, UNIX System III, XENIX and Berkeley BSD.

The third chapter defines the low-level routines which write to the screen. Given the environments that he is supporting, the author is obliged to write these routines at least twice (UNIX and PC), but he actually supplies *five* versions of the code (UNIX hard-wired to the escape codes of the Zenith Z-19 terminal, UNIX via Termcap/Terminfo, UNIX via Curses, PC via BIOS calls and PC by direct writes to video memory). The MS-DOS information, although well-written, is mostly standard stuff, and a bit dated (no mention of VGA, heavy emphasis on CGA 'snow' problems). The UNIX material, especially to a born-and-bred DOSite like myself, is fascinating. As well as presenting the code, the text discusses the relative merits of using Termcap and Curses, and contains a table of experimental results (which show that, if you have a communications bottle-neck, Curses is the better option; but that Termcap is the one to go for if you are short on CPU power).



Chapter 4 provides a set of low-level calls for handling keyboards. Simple functions such as testing for keystrokes under UNIX seem impressively hairy, but the main difficulty here is coping with the differences between terminals' keyboards. Cursor arrow keys and function keys always generate different return codes on different keyboards. It is possible to use the Wordstar technique - ie to put the cursor moving functions onto Ctrl shifted alpha keys - and this approach is described. However, as author Marc Rochkind correctly asserts, this is a sure fire way to irritate users who have splashed out on elaborate, expensive terminals with a full complement of special keys. The solution is to define a virtual keyboard and allow the user to customise your program to support his hardware. Given that keyboards sometimes generate multiple keystrokes on a single key, this is a stiffer problem than you might have bargained for in the keyboard handler. Rochkind solves it with an elegant finite state machine.

Chapter 5 consists of the implementation of an application which uses the library code presented so far. The application is a simple screen editor (but not that simple: it handles multiple buffers). Of course, this editor is portable between MS-DOS and UNIX which, as the author states, makes it something of a freak.

Chapter 6 introduces the concept of windows. Again no fudges: these windows can overlap each other arbitrarily. The library routines must be passed the address of a function to call when a given window needs redrawing - shades of an OOP style system here. To demonstrate the functionality of the window functions, the editor is reworked to use them. Chapter 7, the last chapter, has the same structure as its predecessor, except that it is virtual screens that are introduced (the windows become clipped 'views' of larger screens). The editor is adapted once more to give it the ability to scroll buffers sideways within their windows.

The code in this book is consistently tight and commercial standard. All the functions attempted here are easy to kludge, but hard to do well. It is the sort of library you would write for yourself, if only you had the time. If you do not wish to type all the code in (and there's a lot), you can write off for a copy on disk - but no price is quoted for this service. The other tiny cloud on an otherwise unblemished horizon is the age of the material. We received our review copy around the beginning of October; but it was first published in 1987, so some of the information is out of date. But all in all it is a good effort, and it carries my strong recommendation.

Title: *Advanced C Programming for Displays* Price: £31.80  
Author: Marc J Rochkind Publisher: Prentice Hall  
ISBN: 0-13-010240-70 Pages: 331

## Books Received This Month

*CASE on Trial*, Ed. Kathy Spurr, Paul Layzell.

*Efficient FORTRAN Programming*, by Anton Kryger.

*Running UNIX: an Introduction to SCO UNIX and XENIX*, by Joanne Woodcock, et al.

*Multiview: An Exploration in Information Systems Development*,

by D.E. Avison and A.T. Wood-Harper.

*UNIX Shell Programming*, by Lowell Jay Arthur.

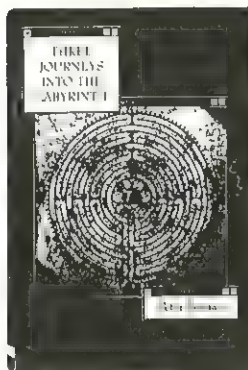
*Windows 3 Companion*, by the Cobb Group.

John Wiley	£19.95	ISBN: 0-471 92893-3	pp241
John Wiley	£28.30	ISBN: 0-471 52894-3	pp184
Microsoft Press	£22.95	ISBN: 1-55615-270-1	pp400
Blackwell	£14.95	ISBN: 0-632-03026-7	pp280
John Wiley	£21.95	ISBN: 0-471-51821-2	pp271
Microsoft Press	£25.95	ISBN: 0-936767-19-7	pp520

## Novel Idea

This column has, in the past, noted that there are some books that are not about computers at all. Many of them do not include code, and some of them aren't even true. We've tried to ignore these sideline novelties. This month, however, Digithurst Ltd sent us a hardback copy of *Three Journeys Into The Labyrinth*, a book written by their MD, Peter Jarman. Much of the book is about people rather than computers, although there are references to Transputers in the first chapter and the popular Autoroute package on page 162. None of it, as far as we can work out, is true. Certainly none of the names checked out.

The book documents the activities of Paul Zobel, who manages to rise above a shady career in Cold War East Germany to run a large electronics company, based in Hertfordshire. Zobel is fascinated by the fringes of artificial intelligence and multimedia. He sets his company to work on a system which will process information in the same way as the human mind (based, as far as I can ascertain, on a 486 system: possibly OS/2). But his past, as they say in the blurbs, is beginning to catch up with him. And as the net draws tighter, his work on the new system begins to mirror the paranoia and conspiracy of his Berlin days (definitely OS/2).



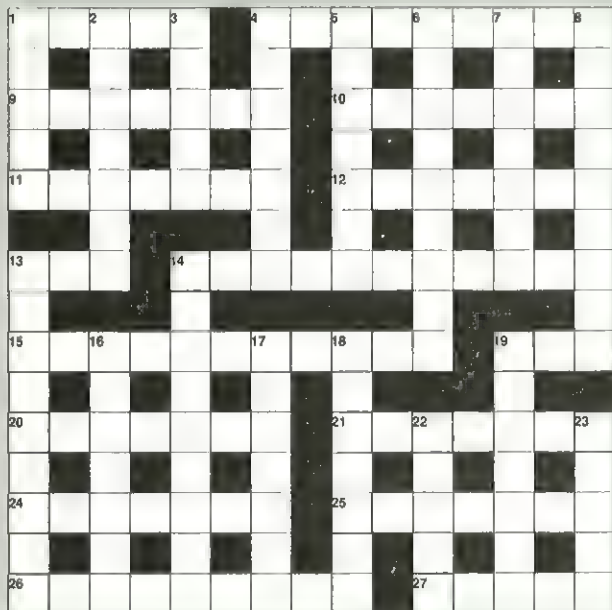
The book is printed under Digithurst's name, which makes one suspect a touch of vanity in the publishing. Jarman has written a perfectly readable novel, applying his own experiences to an intelligent and intriguing plot. *Three Journeys* starts out as a spy thriller, but it can't help toying with Big Ideas. Jarman has obviously been heavily influenced by Umberto Eco, author of *Foucault's Pendulum* and *The Name of The Rose*. The book is peppered with the same sort of fanciful, but appealingly logical notions that Italy's premier bearded semiologist loves to generate. For instance: could the Second World War and the terrorism of the 60's be explained by in-built genetic tendencies to cleanse societies of old stagnating orders? Conspiracy theories are also given a good going over, as are various bits and bobs of information theory and Platonic philosophy. It's the stuff which always seems to appeal to a certain sort of computerist: the information addict, who loves to pore over long listings, speed-read vast manuals, and who downloads every text file he or she can.

If you have Eco or Hofstadter or Dirk Gently or Computer Lib on your bookshelf, I expect you'll catch onto Jarman's own fascination with the subject of this book. For the rest of us, it still works as an entertaining, though faintly bemusing, spy tale. A handy stocking filler for the programmer who thinks he can know everything.

Definitely not enough code examples, though.

Title: *Three Journeys Into The Labyrinth* Author: Peter Jarman  
 Publisher: Digithurst Price: £14.95  
 ISBN: 0-9516631-0-0 Pages: 246

## .EXEWORD DECEMBER



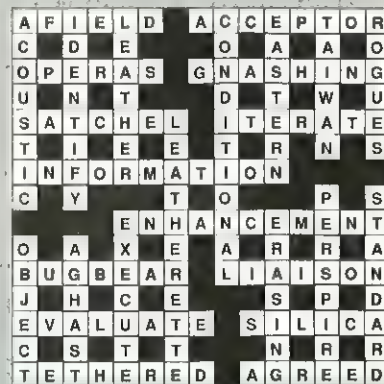
### ACROSS

- 1 & 4 Our message to you now (5,9)
- 9 The season provides much - what a waste (7)
- 10 The southern one 15 in that of your own home (7)
- 11 Listen to the herald angels (7)
- 12 The start is all for mice in the rye maybe (7)
- 13 Seasonal colour is berry nice (3)
- 14 Party game winners get on top of intellects (11)
- 15 Tea does not, though other season's drinks do (11)

- 19 Home to wander round in slippers (3)
- 20 One who fantasises before 4? (7)
- 21 As the Magi go north after next festival (7)
- 24 Feeble reasons for sex cues in the air (7)
- 25 Leave round second Christmas pudding (7)
- 26 Go through dance or programme with timidity (4,5)
- 27 Monsters in the snow (5)

### DOWN

- 1 Third 19 originally - how bitter! (5)
- 2 What to do to the lamp to get your wish (3,4)
- 3 One shout from the fox master maybe...(5)
- 4 ...who goes together with the hounds? (2-5)
- 5 How to conserve year end 9 (7)
- 6 Soundly add and multiply on occasion (9)
- 7 Tie up chicken: just a little bird (7)
- 8 Took off serious things, as one Diana rests a bit (9)
- 13 Dubious Santa's team...(9)
- 14 ...gets the most... (9)
- 16 ...from not very clear in the early syrup (7)
- 17 Bob like a lady of manners in brief (7)
- 18 The heaviest 24h of all (7)
- 19 Give now! (7)
- 22 Perhaps babyish like dear sibling (5)
- 23 Sounds of carols - and the outcomes? (5)



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**£16-£18k neg**

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to £26k

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### SURREY

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### BERKS

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### LONDON

to c£28k

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£16k - £22k

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### OXON

£neg

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### LONDON

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to £30k + car

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to £23k

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## STOB versus the Software Engineers

*Parity Stob, Verity's smarter elder sister, works in the defence sector.  
She has a poor opinion of certain software engineering practices.*

### How to survive a code walk-through.

#### 1) Wrong.

Submitted code:  
#include <stdio.h>

```
main()
{
    printf("hello, world\n");
}
```

Minutes of Review. Attending: Parity Stob (*Programmer*), Bill Dull (*Token Peer Group Representative*), John Straight (*Testing*), Ron Little (*Design/Chair*), Cheryl (*Minutes*).

1. Bill Dull said that Parity Stob had forgotten to do an opening comment. Ms Stob replied that she didn't think that it was necessary with so short a program. Mr Dull said, 'It may be obvious to you what it does, Parity, but it won't be so blooming clear to the poor man that's got to maintain it. I haven't been an AP/2 for 15 years without learning anything.'

The meeting actioned Ms Stob to add an opening comment.

2. Ron Little noted that the "hello, world\n" string was not capitalised, as it was in his design document pseudo code. Ms Stob pointed out that it was not capitalised in the master design document, from which Mr Little's document was derived. Mr Little stated

that the master design document fell beyond Ms Stob's remit.

The meeting actioned Ms Stob to capitalise the "hello, world\n" string.

3. John Straight enquired if `printf()` returned a value. Ms Stob believed that it returned the number of bytes written to `stdout`. Bill Dull observed that it was company policy (and had been for 15 years) to collect *all* return values. Ms Stob enquired what the Dave Allen she was supposed to do with this return value once she had collected it. Ron Little reminded Ms Stob that the purpose of the meeting was to *discover* errors, not to correct them.

The meeting actioned Ms Stob to record the return value from `printf()`.

4. Ron Little asked, 'What if `printf()` fails?' Ms Stob replied...

(*Minutes continue in this vein for several pages*)

...actioned Ms Stob to obtain a printout on nice green and white stripy paper.

The meeting adjourned. Ms Stob has 74 actions against her, plus one oral disciplinary warning (level 1). The code is to be formally re-reviewed, when Ms Stob has actioned the actions.

#### 2) Right.

Submitted code:

```
#include <stdio.h>
man()
{
    printf("hello, cheeky");
}
```

Minutes of Review. Personnel as before.

1. Ron Little said, 'Talk about Freudian slips; isn't it `main()`, not `man()`, hur-hur-hur, eh Parity?' Ms Stob replied, 'Yes Ron, you're right, what was I thinking of.' John Straight said, 'You were still distracted when you typed the string!' Ms Stob couldn't think what had come over her. Bill Dull said that the `}` was out of alignment. Ms Stob was covered in confusion.

Ron Little said that, technically speaking, the meeting should minute actions against Ms Stob, but - hold on a sec, Cheryl love - since it was Our Parity, we'd say no more about it.

2. Bill Dull said he would go ahead and get them in at the *EEPROM and Eaglet*. A pint of Best, a monkey-juice for John and two halves of cooking lager top for the girlies, all right?

Ms Stob said that the girlies would have vodkas and tonics, thanks Ron.

3. The meeting adjourned. On the way out, Ms Stob winked at me.

EXE

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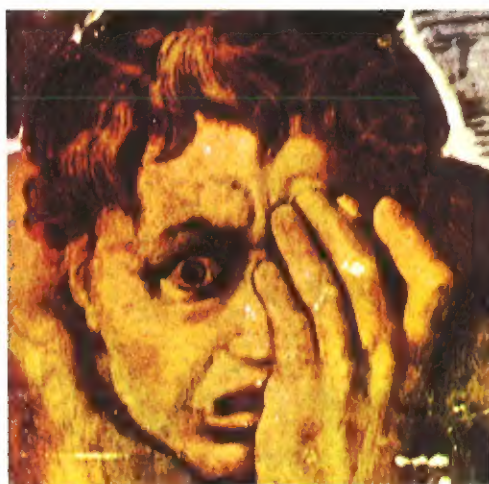
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